INSTRUMENT SHOP

INSTRUCTION MANUAL

PRECISION STEPATTENUATOR

MODELS 60A, 61A, 62A, 63A AND 64A

WEINSCHEL ENGINEERING

GAITHERSBURG, MARYLAND

INSTRUMENT SHOP

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PREFACE

Weinschel Engineering has developed a complete, integrated line of precision microwave instrumentation to meet the insistent demand for increased precision in the measurement of rf power ratios.

Among these instruments are the Models 60A - 64A Precision Stepattenuators whose high precision and reliability characteristics make them well-suited for close-tolerance measurements such as required for the calibration and maintenance of other equipment or as laboratory instruments for experimental work.

Figure 1.1 Front Panel View of Model 64A Precision Stepattenuator

VSWR TEST DATA Date 1-31-67

Model No. 60A Serial No. 286 Job No. 34685

Nominal dB	1000 MC Left Input	1000 MC Right Input	2000 MC Left Input	2000 MC Right Input	MC Left Input	MC Right Input	MC Left Input	MC Right Input
0	1.05	1.08	1.18	1.20				
1	1.04	1.05	1.23	1.24				
2	1.03	1.04	1.18	1.23				
3	1.02	1.06	1.20	1.22				
4	1.04	1.09	1.18	1.14				
5	1.04	1.03	1.24	1.22				
6	1.04	1.02	1.24	1.22				
7	1.08	1.03	1.20	1.21				
8	1.07	1.08	1.24	1.23				
9	1.04	1.03	1.24	1.21				
10	1.03	1.05	1.19	1.15				
0	1.04	1.08	1.10	1.14				
10	1.03	1.03	1.14	1.20				
20	1.04	1.03	1.15	1.21				
30	1.03	1.02	1.10	1.12				
40	1.04	1.03	1.17	1.16				
50	1.04	1.05	1.15	1.21				

Model 64 only

0								
3.0								
3.1								
3.2								
3.3								
3.4								
3.5								
3.6								
3.7								
3.8								
3.9								
4.0								

Calibration standards as applicable are traceable to the National Bureau of Standards.

IM#6

VSWR TEST DATA

Date 1-31-67

Model No. 60A Serial No. 286 Job No. 34685

Nominal DB	1000 MC Left Input	1000 MC Right Input	2000 MC Left Input	2000 MC Right Input	MC Left Input	MC Right Input	MC Left Input	MC Right Input
0	1.05	1.08	1.18	1.20				
1	1.04	1.05	1.23	1.24				
2	1.03	1.04	1.18	1.23				
3	1.02	1.06	1.20	1.22				
4	1.04	1.09	1.18	1.14				
5	1.04	1.03	1.24	1.22				
6	1.04	1.02	1.24	1.22				
7	1.08	1.03	1.20	1.21				
8	1.07	1.08	1.24	1.23				
9	1.04	1.03	1.24	1.21				
10	1.03	1.05	1.19	1.15				
0	1.04	1.08	1.10	1.14				
10	1.03	1.03	1.14	1.20				
20	1.04	1.03	1.15	1.21				
30	1.03	1.02	1.10	1.12				
40	1.04	1.03	1.17	1.16				
50	1.04	1.05	1.15	1.21				
Model 64 only 0								
3.0								
3.1								
3.2								
3.3								
3.4								
3.5								
3.6								
3.7								
3.8								
3.9								
4.0								

Calibration standards as applicable are traceable to the National Bureau of Standards.

IM#6

SECTION I

GENERAL DESCRIPTION

1.1 SCOPE OF MANUAL

This Instruction Manual is for use with the Precision Stepattenuator Models 60A through 64A manufactured by Weinschel Engineering Co., Inc., Gaithersburg, Maryland. The Model 64A is shown in figure 1.1.

This Instruction Manual contains the description, operation and maintenance procedures of the Stepattenuators. For specific topics, refer to the Table of Contents, List of Illustrations, or List of Tables.

1.2 PURPOSE OF EQUIPMENT

Typical applications of the Precision Stepattenuator include:

1) the calibration of the output system of signal generators
2) use as a reference standard in IF-type insertion loss test sets
3) the calibration of antenna pattern test sets
4) precision VSWR measurements (by using the Stepattenuator to adjust the rf level to maintain a constant probe output), and
5) the calibration of rf filters, directional couplers, etc.

1.3 SPECIFICATIONS

The specifications for the instrument are listed in table 1.1.

TABLE 1.1

SPECIFICATIONS

Specification	Descriptive Data (Model)				
	60A	61A	62A	63A	64A
Dimensions (Inches)					
Height	8-3/4	8-3/4	8-3/4	8-3/4	8-3/4
Width	19	7	7	7	19
Depth Behind Panel	14-3/4	14-3/4	14-3/4	14-3/4	14-3/4
Weight (lb.)					
Net	29	15	15	15	42
Shipping	47	20	20	20	55
Attenuation Range	0-60 db	0-10 db	0-50 db	0-4 db	0-64 db

(Cont.)

TABLE 1.1 (Cont.)

Specification	Descriptive Data (Model)				
	60A	61A	62A	63A	64A
Drum C	0-50 db in 10-db steps	-	0-50db in 10-db steps	-	0-50 db in 10 db steps
Drum B	0-10 db in 1-db steps		-	-	0-10 db in 1-db steps
Drum A	-	-	-	0-3.0 db in one step; 3.0-4.0 db in 0.1-db steps	
Frequency Range	DC to 2000 mc				
Impedance	50 ohms nominal				
VSWR (When terminated in 50-ohm load)	DC to 1 kmc: 1:15 max DC to 2 kmc: 1:25 max				
Power Input (Max)	100 mw CW for maximum accuracy 1 watt average with reduced accuracy				
Maximum Deviation of Insertion Loss from Nominal at DC:	1 to 5 db: 0.02 db 6 to 10 db: 0.05 db 20 to 50 db: 0.10 db				
Maximum Change from DC Value of Incremental Insertion Loss above Zero Loss:	DC to 2000 MC 3.0 - 4.0 db: .05 db for each switch position 0 - 10 db: .1 db for each switch position 0 - 50 db: .1 db/10 db for each switch position				
Maximum Insertion Loss in Zero Position (Per Drum):	At DC: 0.005 db At 1000 MC: 0.4 db At 2000 MC: 0.5 db				
Tracking of Incremental Loss for .1 db Steps (DC - 2000 MC):	When changing from any switch position between 3 and 4 db to an adjacent switch position the change of insertion loss is between .08 and .12 db.				
Calibration Data:	Insertion loss for each switch position at DC, 1000 MC and 2000 MC, to be measured in a 50 ohm system. Female input only. Voltage division at DC when terminated in 50 ohms. Female input only. VSWR at 1000 MC and 2000 MC for both inputs to each drum at each switch position.				

(Cont.)

TABLE 1.1 (Cont.)

Specification	Descriptive Data (Model)				
	60A	61A	62A	63A	64A
Calibration Data: (Cont.)	The insertion loss and voltage division calibration data are laminated and mounted on front panel. VSWR data are on test report in instruction book. VSWR data are stated to the nearest observed .01. Voltage division and insertion loss data are stated to the nearest .01 db.				
Calibration Accuracy:					
At 1000 and 2000 MC:	Zero insertion loss -- ±0.01 db Incremental insertion loss -- ±0.02 db/10 db or 0.02 db whichever is greater. VSWR -- 2%				
At DC:	Voltage division and insertion loss -- ±0.01 db up to 40 db, ±0.02 db at 50 db.				
Connectors	Input: Female panel-mounted type N Output: Male panel-mounted type N				
Repeatability	The maximum variation in insertion loss due to mechanical wear as the coaxial switch is brought to a given position repeatedly does not exceed 0.01 db.				

1.4 DESCRIPTION

1.4.1 MECHANICAL. The Models 61A through 63A each contain one attenuator group or drum assembly; the Model 60A contains two drum assemblies, and the Model 64A contains three. Each drum assembly is mechanically independent and composed of individual attenuator assemblies mounted on shielded coaxial selector switches. Accurate positioning of the individual attenuator assemblies as selected by the main dial is insured by a spring-loaded detent assembly. A worm gear driven by the LOCK knob controls mating of the attenuator assemblies to the coaxial switch contacts.

CAUTION

Always rotate the LOCK knob fully counterclockwise before turning the main dial (upper knob). Bring the main dial to its final position before engaging the coaxial switches by rotating the LOCK knob fully clockwise.

Models 60A and 64A Stepattenuators are complete in one unit ready for mounting into a standard 19-inch relay rack; models 61A through 63A are designed for bench operation. All models have the operating controls, electrical connections and Calibration Data cards on the front panel. The description and function of the controls and connectors are listed in table 1.2.

TABLE 1.2

DESCRIPTION AND FUNCTION OF FRONT PANEL ITEMS

Item	Description and Function
Main Dial (Upper knob)	An attenuator drum assembly with a scale calibrated directly in decibels which is rotated to select desired attenuation.
LOCK knob	A worm gear which firmly connects the individual attenuator assemblies to the coaxial switches.
Connectors	One female and one male panel-mounted type N arranged to allow separate input and output connections to each drum assembly. The Step-attenuators are bilateral.

1.4.2 ELECTRICAL. The Stepattenuators do not contain fuses or tubes and do not require primary ac power. Each group of attenuators has a separate input and output connector as shown in figure 1.1. Since these attenuators are bilateral, input power can be applied to either connector. Two or more groups can be connected in series by about 12 inches of RG-9/U coaxial cable (not furnished) terminated at one end with a type UG-21B/U connector and on the other end with a type UG-23B/U connector. Aluminum jacketed interconnecting cables are included, however, with the Model 60A and 64A in order to cascade individual switches. In operation, the Stepattenuator must be properly terminated prior to application of input power; this power must not exceed 100 mw maximum (or 2.2 volts rms) to insure calibrated accuracy.

Each drum assembly is composed of stable coaxial precision attenuation assemblies electrically independent of other groups on the same instrument. The individual coaxial attenuator assemblies are made of precision components arranged to form one or more attenuator T-sections. The schematic diagram of the Step-attenuator is shown in figure 1.2.

TABLE 6.2 (Cont.)

Quantity	Nomenclature	Weinschel Part No.
	Drum B Parts Breakdown (Cont.)	
1	Pad, Attenuator, 6 db	B89-174-6
1	Pad, Attenuator, 7 db	B89-174-7
1	Pad, Attenuator, 8 db	B89-174-8
1	Pad, Attenuator, 9 db	B89-174-9
1	Pad, Attenuator, 10 db	B89-174-10
1	Switch Assembly	D89-97-1
1	Cable Assembly	B101-175
1	Cable Assembly	B101-16
	Drum C Parts Breakdown	
1	Pad, Attenuator, 0 db	B89-174-00
1	Pad, Attenuator, 10 db	B89-174-10L
1	Pad, Attenuator, 20 db	B89-174-20
1	Pad, Attenuator, 30 db	B89-174-30
1	Pad, Attenuator, 40 db	B89-174-40
1	Pad, Attenuator, 50 db	B89-174-50
1	Switch Assembly	D89-97-2
1	Cable Assembly	B101-175
1	Cable Assembly	B101-16

APPENDIX I

WEINSCHEL ENGINEERING APPLICATION NOTE NO. 4

IM #54

September 1963

Application Note No. 4

WEINSCHEL
ENGINEERING

DUAL CHANNEL INSERTION LOSS TEST SET

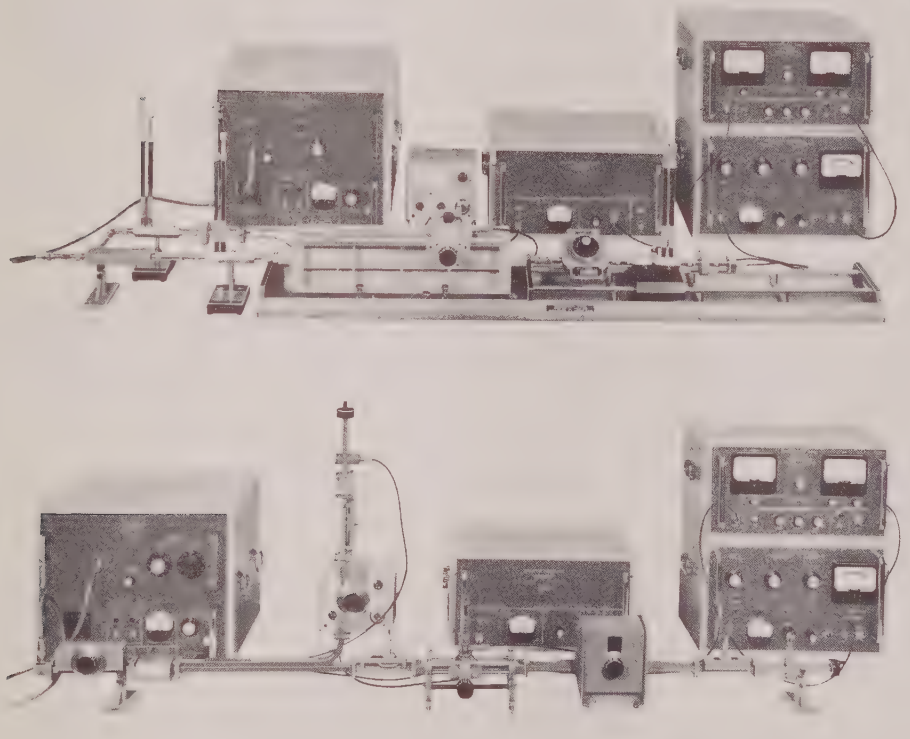


Figure Number 1

INTRODUCTION

The virtual elimination of errors caused by oscillator power drift and the utilization of the tremendous resolution possible with null detection, makes the Dual Channel Insertion Loss Test Set a powerful tool for the precise calibration of attenuators and the determination of the usually smaller insertion loss of cable assemblies, switches, and similar devices. The system to be described permits direct measurement of insertion losses up to 35 db with an accuracy of 0.02 db per 10 db.* Using rf substitution this range can be extended to 55 db. Measurements can be repeated to 0.01 db per 10 db and the resolution is approximately 0.001 db.

Because oscillator power drift is automatically nullified, this parallel audio substitution system can be used to make direct precise measurements of the small losses in cables, rotary joints, and similar devices.

The calibration accuracy is based principally on the square law detection characteristics of barretters and the accuracy of audio attenuators. This system uses the recognized principles of audio substitution and is an extension of the basic single channel audio substitution system described in Weinschel Engineering Application Note No. 1[1].

Although the particular rf equipment described is for the frequency range from 50 to 60,000 mc, the method is applicable at higher and lower frequencies.

* Or 0.01 db whichever is greater.

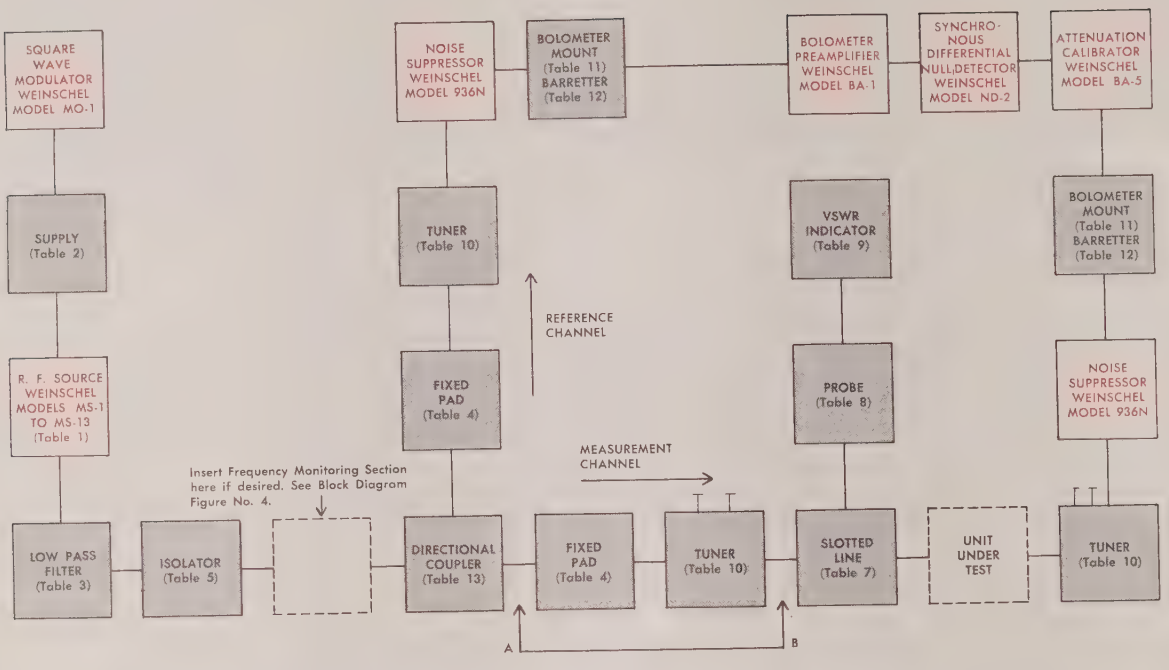

SQUARE WAVE MODULATOR WEINSCHEL MODEL MO-1
SUPPLY (Table 2)
R. F. SOURCE WEINSCHEL MODELS MS-1 TO MS-13 (Table 1)
LOW PASS FILTER (Table 3)
ISOLATOR (Table 5)
Insert Frequency Monitoring Section here if desired. See Block Diagram Figure No. 4.
DIRECTIONAL COUPLER (Table 13)
FIXED PAD (Table 4)
TUNER (Table 10)
NOISE SUPPRESSOR WEINSCHEL MODEL 936N
BOLOMETER MOUNT (Table 11) BARRETTER (Table 12)
REFERENCE CHANNEL
MEASUREMENT CHANNEL
BOLOMETER PREAMPLIFIER WEINSCHEL MODEL BA-1
SYNCHRO-NOUS DIFFERENTIAL NULL DETECTOR WEINSCHEL MODEL ND-2
VSWR INDICATOR (Table 9)
PROBE (Table 8)
SLOTTED LINE (Table 7)
UNIT UNDER TEST
ATTENUATION CALIBRATOR WEINSCHEL MODEL BA-5
BOLOMETER MOUNT (Table 11) BARRETTER (Table 12)
NOISE SUPPRESSOR WEINSCHEL MODEL 936N
TUNER (Table 10)
A
B

Figure Number 2: Block Diagram of Coaxial Dual Channel Insertion Loss Test Set

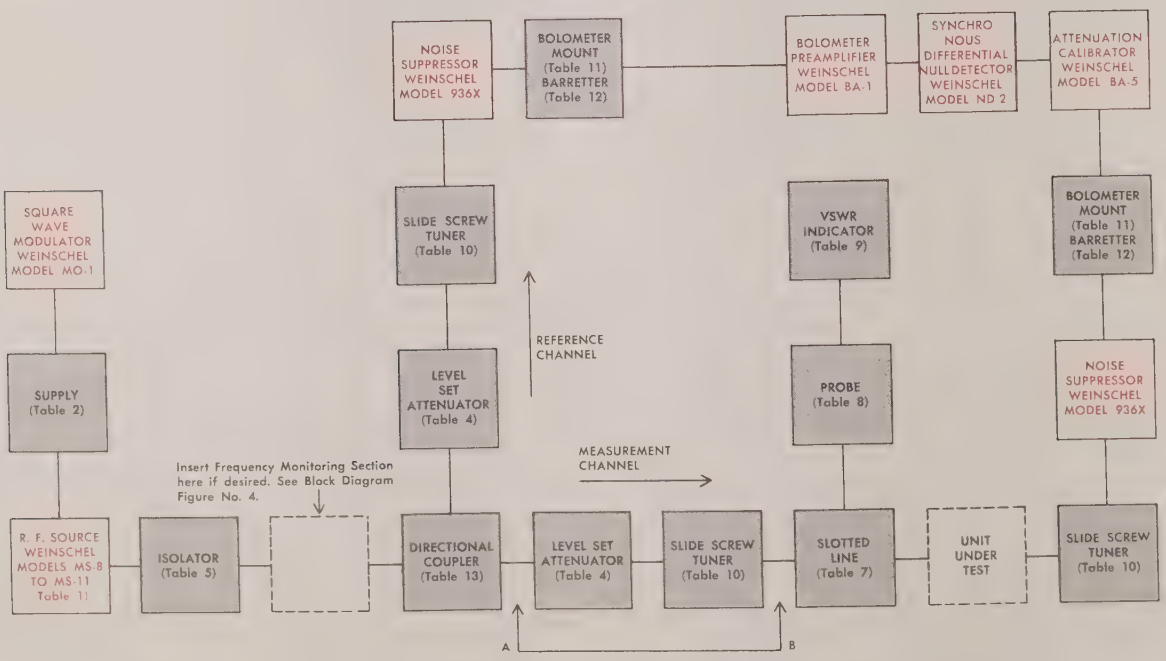

SQUARE WAVE MODULATOR WEINSCHEL MODEL MO-1
SUPPLY (Table 2)
R. F. SOURCE WEINSCHEL MODELS MS-8 TO MS-11 Table 11
ISOLATOR (Table 5)
Insert Frequency Monitoring Section here if desired. See Block Diagram Figure No. 4.
DIRECTIONAL COUPLER (Table 13)
LEVEL SET ATTENUATOR (Table 4)
SLIDE SCREW TUNER (Table 10)
NOISE SUPPRESSOR WEINSCHEL MODEL 936X
BOLOMETER MOUNT (Table 11) BARRETTER (Table 12)
SLIDE SCREW TUNER (Table 10)
REFERENCE CHANNEL
MEASUREMENT CHANNEL
BOLOMETER PREAMPLIFIER WEINSCHEL MODEL BA-1
SYNCHRO NOUS DIFFERENTIAL NULL DETECTOR WEINSCHEL MODEL ND 2
VSWR INDICATOR (Table 9)
PROBE (Table 8)
SLOTTED LINE (Table 7)
UNIT UNDER TEST
ATTENUATION CALIBRATOR WEINSCHEL MODEL BA-5
BOLOMETER MOUNT (Table 11) BARRETTER (Table 12)
NOISE SUPPRESSOR WEINSCHEL MODEL 936X
SLIDE SCREW TUNER (Table 10)
A
B

Figure Number 3: Block Diagram of the Waveguide Dual Channel Insertion Loss Test Set

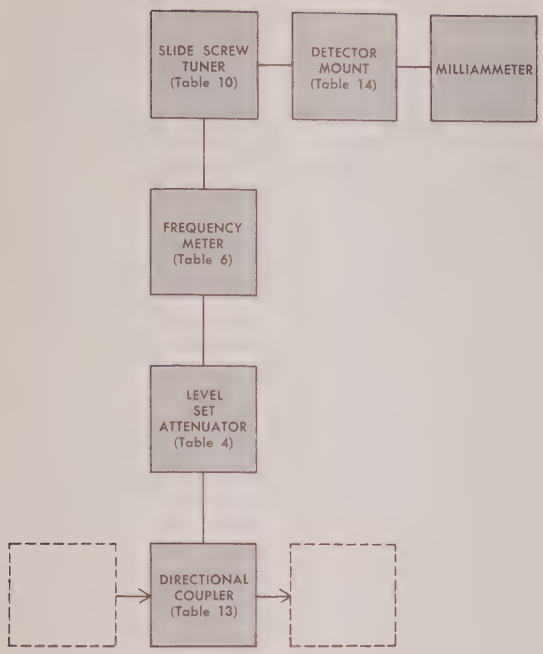


Figure Number 4: Block Diagram of the Frequency Monitoring Section

DESCRIPTION OF THE SYSTEM

Block diagrams of a coaxial line and a waveguide measuring system are shown in Figures 2 and 3. In both cases, the rf signal is first divided into two channels. The detected outputs of both channels are amplified and then balanced to zero in the Model ND-2 Synchronous Differential Null Detector. When the unit to be tested is inserted, enough audio attenuation is removed from the Model BA-5 Attenuation Calibrator to keep the signal levels at the ND-2 constant and balanced. The measured rf attenuation is then equal to the difference in the BA-5 attenuator settings. The measurement is substantially unaffected by changes in the rf level since both signals are derived from the same source and are balanced to zero in the output.

In both the coax and waveguide systems, a stable rf source at the selected frequency is 100% square wave modulated at 1 kc. After passing through a low pass rf filter and either a resistive or ferrite rf isolator, the signal is divided by a directional coupler into a *measurement channel* and a *reference channel*.

The signal in the *reference channel* passes through an isolation pad and then to a tuner which is used to optimize the power transfer to the terminating barretter. A Weinschel Model 936 Noise Suppressor is inserted before the barretter and the BA-1 Bolometer Preamplifier. This unit increases the reliability of the measurement by isolating audio currents that may flow in the ground system when certain combinations of equipment are used.

In the *measurement channel,* the rf power first goes to an isolation pad and then to a tuner. This tuner is used to present a matched generator at the insertion point but it is not needed when the isolation pad is well matched. A slotted line and a tuner to match the terminating barretter and noise suppressor completes the microwave plumbing in the *measurement channel.*

Both barretters must be operated in their square law region, i.e., the operating range where the voltage at the 1 kc modulation frequency developed across the barretter is proportional to the rf power absorbed by the barretter.[2,3] Operation in this region can be assured by keeping the audio output voltage from the barretters below 2 mv (rms).

PROCEDURE

To measure insertion loss, first the tuner and bolometer in the *reference channel* are put at the end of the slotted line in the *measurement channel* and the combination is tuned for optimum match. Then the terminating bolometer in the *measurement channel* is matched using the same slotted line. As a final tuning adjustment, the generator impedance in the *measurement channel* must be matched.

In order to do this, the equipment between points A and B in Figures 2 and 3 is taken out of the line, turned around and then put in place of the bolometer at the end of the slotted line. Using the tuned *measurement channel* bolometer as a termination, the impedance into the generator pad is matched with the tuner. This procedure assumes that the isolation of this pad or ferrite isolator is greater than 10 db.

Next, the rf level is checked to make certain that the bolometers are operating in the square law region. This is done by measuring the 1 kc audio voltage into the BA-5 and setting this level below 2 mv. The stabilized gain of the BA-5 is set so that at minimum gain and with the substitution attenuators set to zero a 2 mv signal will deflect the output meter to the 2 db point.

The precision audio attenuator in the BA-5 Attenuator Calibrator is then set at slightly more attenuation than the expected insertion loss of the unit to be tested or calibrated. Gain in the *reference channel* and the phasing adjustments on the ND-2 Differential Null Detector are used to produce a null reading on the ND-2. The unit to be tested is

then inserted in the *measurement channel* and audio attenuation is removed from the BA-5 until the null reading is restored on the ND-2. The rf attenuation is then equal to the difference in the audio attenuator markings on the BA-5.

RANGE EXTENSION

The procedure described above is for the direct measurement of insertion loss up to 35 db with an accuracy of 0.02 db per 10 db. To increase the range of insertion loss measurements, partial rf substitution can be used providing that the source has sufficient power output. For example, if the source has an output of 200 mw, the range can be extended 20 db to a total of 55 db with only a slight deterioration in accuracy. A lower power generator is satisfactory if ferrite isolators are used in place of the buffer attenuator pads.

In making extended range measurements using partial rf substitution, an accurately calibrated 20 db attenuator is put in the *measurement channel* and the initial system balance is made. The unit to be measured is then inserted and the calibrated rf attenuator is removed together with enough audio attenuation to rebalance the system. The value of the unknown attenuator is then equal to the sum of audio attenuation that was removed and the value of the calibrated attenuator.

If the attenuator under test is continuously variable the range can be extended by measuring the attenuation in two steps. In the first step 20 db is measured carefully several times and the attenuator dial position noted. The attenuator is then set at this point and the generator power increased to provide the original reference level at the *measurement channel* detector. Using this attenuator setting as a zero base, a second step of 35 db is then measured.

ELECTRONIC INSTRUMENTS— REQUIREMENTS AND DESCRIPTION

Microwave and some electronic equipment suitable for use in the dual channel measuring system are shown in Tables 1 through 14. Certain pieces of electronic equipment, however, were designed specifically for this application. These are described below.

SYNCHRONOUS DIFFERENTIAL NULL DETECTOR

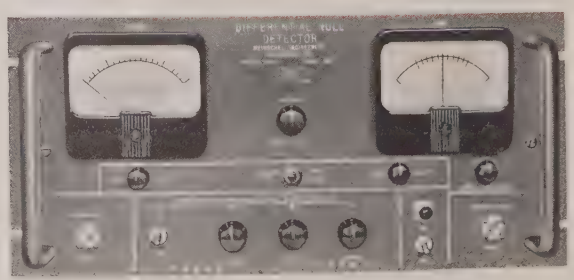
The Weinschel Engineering Model ND-2 Synchronous Differential Null Detector is the heart of the dual channel insertion loss system. This instrument was designed to display the amplitude balance between two synchronous 1 kc signals. Many features such as logarithmic amplifiers and a low noise synchronous detector are used so that the balance can be made accurately and conveniently. This balance is maintained over a wide amplitude range providing that the ratio of the two signals remains constant. A difference in phase or a change in the ratio of the two signals, however, will produce an unbalance indication. At a typical setting of sensitivity, the full scale indication on the ND-2 is equivalent to a change of ± 0.02 db in the *measurement channel* rf signal level. Under ideal operating conditions, this full scale deflection can be set as high as ± 0.001 db.

A block diagram of the ND-2 is shown in Figure 6. The *reference channel* input signal is applied to the constant amplitude phase shift network, amplified and then fed to the adder circuit where its vector value is compared with that of the signal from the *measurement channel*. The resulting unbalance signal is fed to the lin-log amplifier, a harmonic rejection trap and a sensitivity control.

The gain of the lin-log amplifier is approximately logarithmic to provide maximum sensitivity for small signals close to the null and to prevent the amplifier from being overloaded by large unbalance signals. The signal from this amplifier is then rectified and powers a meter which gives a coarse indication of balance. This meter is used to make the initial phase and amplitude adjustments.

The same output signal from the lin-log amplifier is applied to the synchronous detector which uses as a reference a square wave *reference channel* signal from the output of the phase shift network. A meter which is used for the final balance adjustments

Figure Number 5: Model ND-2, Synchronous Differential Null Detector



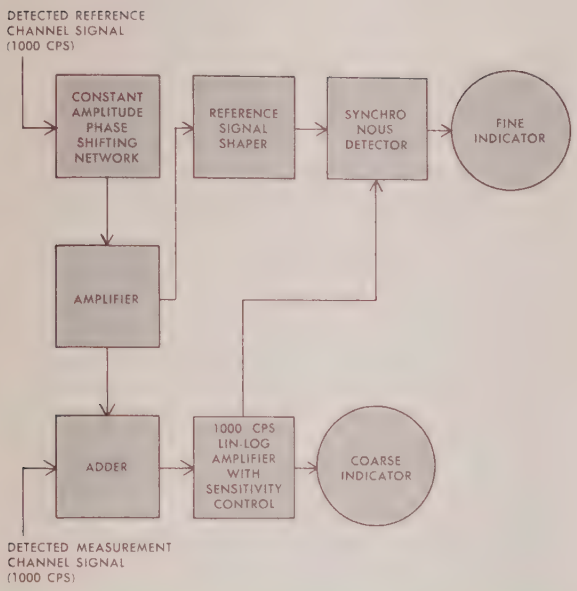


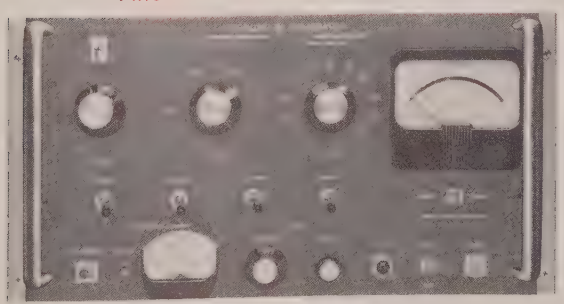
Figure Number 6: Block Diagram of the Weinschel Synchronous Differential Null Detector, Model ND-2

is connected across the output of the synchronous detector. The synchronous detector increases the range of measurements because it responds to signal voltages but it does not react appreciably to noise.

ATTENUATOR CALIBRATOR

The Model BA-5 Attenuator Calibrator in the *measurement channel* is used as the measurement standard and is, therefore, one of the most important instruments in the system. It consists of an accurate audio substitution attenuator standard, a bolometer preamplifier, a high gain tuned amplifier and a detector with an output meter. In order to eliminate any non-linearity of the amplifier as a possible source of measurement error the audio substitution attenuator precedes the amplifier. The amplifier then operates at a substantially constant level during any one measurement. The output meter on the BA-5 is used only to monitor the level of the *measurement channel* to insure that the system is operating in the proper range. A signal from the output of the BA-5 is used by the ND-2 Synchronous Differential Null Detector in balancing the two channels of the system.

Figure Number 7: Model BA-5, Attenuation Calibrator



A bolometer bias current supply is included in the Model BA-5. This biasing circuit has a protective crystal diode in parallel with the bolometer to limit the peak discharge current and thus protect the bolometer from transients when applying or disconnecting the ac power to the instrument or connecting or disconnecting the bolometer to the instrument.

RF SOURCE

The rf power source must be stable in both frequency and power output so that no change in the characteristics of the unit under test will occur during the measurement. The dual channel technique reduces the effect of any change in source output but if the unit under test is non-linear or frequency sensitive, its measured value may change. A change in the rf frequency may also unbalance the system if the bolometers are critically tuned.

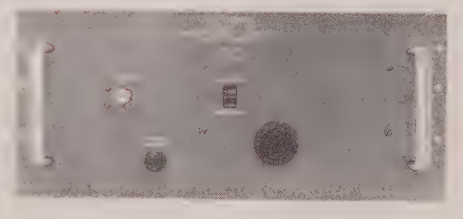


Figure Number 8: Model MS-8, RF Source

The rf power source must be 100% square wave modulated at a frequency of 1 kc. It is important that this frequency be very stable since tuned amplifiers are used in both channels. A very small change in the modulation frequency can result in a phase unbalance in the signals applied to the Synchronous Differential Null Detector.

It is recommended that the appropriate Weinschel Engineering RF Source, MS-8, -9, -10, -11, -12, -13, -16 or -17 be used with the Model MO-3 or MO-5 Power Supplies since these supplies use a tuning fork stabilized 1 kc modulator and the voltages are closely regulated. At higher frequencies one of the other sources shown in Table 1 can be used with the tuning fork stabilized oscillator in the Weinschel Engineering Model MO-1 Modulator. The output of the MO-1 is sufficient to modulate most test oscillators. The modulation frequency of either the MO-1, MO-3, or MO-5 is held to 1000/ $\pm$ 0.1 cps.

APPLICATION NOTE NO. 4

REFERENCE CHANNEL AMPLIFIER

The linear range of the *reference channel* is not too critical since it operates at substantially constant level throughout the measurement. Convenience, however, dictates a fairly wide dynamic range and a variable gain to allow easy adjustment of the signal level at the output of the *reference channel*. It is necessary, however, that the gain of this channel be very stable. The Weinschel Engineering Model BA-1 Bolometer Amplifier fulfills these requirements.

Figure Number 9:
Model BA-1,
olometer Amplifier

CONCLUSION

A system has been described for the measurement of insertion loss up to 35 db with an accuracy of better than 0.02 db per 10 db.* This measurement can be made at frequencies above 1 mc for which power sources and bolometers are available. Also described is the application of Weinschel Engineering's Attenuator Calibrator, Model BA-5 and Synchronous Differential Null Detector, Model ND-2. The Model ND-2 was specifically designed for this measuring system.

To increase the range of insertion loss measurements, partial rf substitution can be used providing that the source has sufficient power output. For example, if the source has an output of 200 mw, the range can be extended 20 db to a total of 55 db, with only a slight deterioration in accuracy.

* Or 0.01 db whichever is greater.

BIBLIOGRAPHY

1.* Weinschel Engineering Application Note No. 1, "Single Channel Insertion Loss Test Set".

2.* G. U. Sorger and B. O. Weinschel, "Precise Insertion Loss Measurements Using Imperfect Square Law Detectors and Accuracy Limitations Due to Noise," pp. 55-68, IRE Transactions on Instrumentation, October 1955, reprinted as Weinschel Engineering Note No. 1.

3.* B. O. Weinschel, "Insertion Loss Test Sets Using Square Law Detectors," pp. 160-64, IRE Transactions on Instrumentation, October 1955, reprinted as Weinschel Engineering Note No. 2.

*Available on request from Weinschel Engineering.

TABLE 1: R. F. SOURCES

Frequency Range (GC)	Manufacturer*	Model Number	Power Supply Required
0.05 — 0.25	Weinschel	MS-1	None
0.05 — 0.25	Weinschel	MS-12	Weinschel Model MO-3** or Weinschel Model MO-5**
0.25 — 0.92	Weinschel	MS-2	None
0.25 — 0.92	Weinschel	MS-13	Weinschel Model MO-3** or Weinschel Model MO-5**
0.90 — 2.00	Weinschel	MS-3	None
0.90 — 2.20	Weinschel	MS-8	Weinschel Model MO-3** or Weinschel Model MO-5**
2.00 — 4.20	Weinschel	MS-9	Weinschel Model MO-3** or Weinschel Model MO-5**
4.0 — 7.30	Weinschel	MS-10	Weinschel Model MO-3** or Weinschel Model MO-5**
7.2 — 10.50	Weinschel	MS-11	Weinschel Model MO-3** or Weinschel Model MO-5**
8.2 — 12.4	Varian	X-13	See Table 2
10.0 — 15.0	Weinschel	MS-16	Weinschel Model MO-5**
12.4 — 17.5	Varian	X-12	See Table 2
15.0 — 20.0	Weinschel	MS-17	Weinschel Model MO-5**
22.0 — 25.0	Raytheon	2K33B	See Table 2
22.0 — 25.0	Varian	VA-96	See Table 2
22.3 — 30.0	Raytheon	QKK-289	See Table 2
29.7 — 33.5	Raytheon	QKK-290	See Table 2
33.5 — 36.2	Raytheon	QKK-291	See Table 2
35.1 — 39.7	Raytheon	QKK-292	See Table 2
37.1 — 42.6	Raytheon	QKK-293	See Table 2
41.7 — 50.0	Raytheon	QK-294	See Table 2
50.0 — 60.0	Raytheon	QK-295	See Table 2

*See Code of Manufacturers, Table 15.
**Includes Modulator.

TABLE 2: KLYSTRON POWER SUPPLIES

Manufacturer*	Model Number
PRD	815
Sperry	62A1
FXR	Z815B

*See Code of Manufacturers, Table 15.

TABLE 3: LOW PASS FILTERS

Cutoff Frequency (GC)	Manufacturer*	Model Number
.044	Sierra	184
.076	Sierra	184
135	Sierra	184
230	Sierra	184
400	Sierra	184
400	Bird	844
.500	Narda	3010-500
7	H-P	360-A
1 0	Narda	3010-1000
1 2	Bird	819-1200
1.2	H-P	360-B
2.1	Narda	3010-2100
2.2	H-P	360-C
4.1	H-P	360-D
4 2	Narda	3010-4200

*See Code of Manufacturers, Table 15.

TABLE 4: COAXIAL AND WAVEGUIDE ATTENUATORS

COAXIAL		
Frequency Range (GC)	**Manufacturer***	**Model Number**
DC-1 0	Weinschel	Model 905 (Variable)
DC 1 0	Weinschel	Model 10 (Fixed)
DC 3 0	Weinschel	Model 50 (Fixed)
DC 5 0	Weinschel	Model 650 (Fixed)
1 0-12 4	Weinschel	Model 210 (Fixed)
1 0-12 4	Weinschel	Model 503 (Fixed)

WAVEGUIDE				
Frequency Range (GC)	**Manufacturer's* Model Number**			
	FXR	**H-P**	**Narda**	**PRD**
2.6 — 3.95	S-155-A	S-375-A	734	171
3.95 — 5.85	H-155-A	G-375-A	733	162
5.85 — 8.2	C-155-A	J-375-A	732	161
7 05 — 10.0	W-155-A	H-375-A	731	160
8.2 — 12.4	X-155-A	X-375 A	730	159
12.4 — 18.0	Y-151-A	P-375-A	729	189
18.0 — 26.5	K-151-A	K-375-A	728	190
26.5 — 40.0	U-151-A	R-375-A	V-727	191
33.0 — 50.0	Q-151-A		Q-727	
50.0 — 75.0	M-151-A		M-727	179
60.0 — 90.0	E-151-A		E-727	

*See Code of Manufacturers, Table 15.

TABLE 5: ISOLATORS

Manufacturer*	Model Number	Manufacturer*	Model Number
Rantec Airtron Kearfott Cascade Raytheon	Consult Manufacturer for Proper Model for Your Needs	Sylvania TRG Inc. Micromega Narda PRD FXR	Consult Manufacturer for Proper Model for Your Needs

* See Code of Manufacturers, Table 15.

TABLE 6: FREQUENCY METERS

Frequency Range (GC)	Manufacturer's* Model Number			
	FXR	**H-P**	**Narda**	**PRD**
0.2 — 0 5			804	
0.250 — 1.0				587A
0.5 — 2 4			805, 806	
1.0 — 4.0	N410A	536A		
3.95 — 5.85	H410A	G532A		532
5.85 — 8 20	C410A	J532A		533
8.20 — 12.4	X410A	X532A	840	535
12.4 — 18.0	Y410A	P532A		536
18.0 — 26 5	K410A	K532A		537
26.5 — 40 0	U410A	R532A		538
33.0 — 50.0	Q410		Q807	
50.0 — 75.0	M410		M807	
60.0 — 90 0	E410		E807	

*See Code of Manufacturers, Table 15.

TABLE 7: SLOTTED LINES

COAXIAL		
Frequency Range (GC)	**Manufacturer***	**Model Number**
.0375 — 3.0	Alford	1026B-16[1]
.1 — 4.0	Alford	2181-6[2]
.5 — 4.0	H-P	805-C
.45 — 4.0	Narda	230-N, 230-C, 230-5/8, 230-7/8, 230-SC
1.0 — 4.0	FXR	N-101-A[3]
1.0 — 4.0	PRD	215-A[3]
1.5 — 12.4	Narda	231-N, 231-C, 231-TNC[3]
3.0 — 12.0	H-P	806-B[3]
4.0 — 10.0	FXR	N-101-B[3]
4.0 — 10.0	PRD	205-A[3]

WAVEGUIDE				
Frequency Range (GC)	**Manufacturer's* Model Number**			
	FXR	**Narda**	**H-P**	**PRD**
2.60 — 3.95	S-101-A[3]	224[3]	S-810[3]	209-A[3]
3.95 — 5.85	H-101-A[3]	223[3]	G-810-B[4]	201-A[3]
5.85 — 8.2	C-101-A[3]	222[3]	J-810-B[4]	204-B[3]
7.05 — 10.0	W-101-A[3]	221[3]	H-810-B[4]	202-B[3]
8.2 — 12.4	X-101-A[3]	220[3]	X-810-B[4]	203-D[3]
12.4 — 18.0	Y-102-A	219[3]	P-810-B[4]	210-A
18.0 — 26.5	K-102-A	218[3]	K-815-B[4]	211-A
26.5 — 40.0	U-102-A[5]	V-217[3]	R-815-B[4]	212-A
33.0 — 50.0	Q-103 A[5]	Q-217[3]		
50.0 — 75.0	M-103-A[5]	M-217[3]		216
60.0 — 90.0	E-103-A[5]	E-217[3]		

* See Code of Manufacturer, Table 15.

[1] Requires one Type 1122C Type N Tapered Reducer.
[2] Requires one Type 2170 Type N Tapered Reducer.
[3] Requires Tuning Probe, See Table 8.
[4] Used with Universal Probe Carriage and Tuning Probe, See Table 8.
[5] Requires Detector Mount.

TABLE 8: PROBES

Freq. Range (GC)	Manufacturer*	Model Number
1.0 - 12.4	FXR	B-200-A tunable
1.0 - 12.4	PRD	250-A tunable
3 - 18.0	Narda	229 tunable
3.0 — 18.0	H-P	444-A untuned
18.0 — 40.0	H-P	446-B untuned

* See Code of Manufacturers, Table 15.

TABLE 9: VSWR INDICATORS

Manufacturer*	Model Number
H-P	415-C
PRD	277B
FXR	B-812-A
Narda	441B

* See Code of Manufacturers, Table 15.

TABLE 10: TUNERS

COAXIAL TUNERS		
Frequency Range	**Manufacturer**	**Model Number**
40 MC — 400 MC	Weinschel	DS-109H
20 GC — 2.0 GC	Weinschel	DS-109LL
40 GC — 4.0 GC	Weinschel	DS-109L
75 GC — 10.0 GC	Weinschel	DS-109

WAVEGUIDE TUNERS				
Frequency Range (GC)	**Manufacturer's* Model Number**			
	H-P	**PRD**	**Narda**	**FXR**
2.60 — 3.95	S-870-A	309-A	964	S-311-A S-312-A
3.95 — 5.85	G-870-A	300-A	963	H-311-A H-312-A
5.85 — 8.20	J-870-A	305-A	962	C-311-A C-312-A
7.05 — 10.0	H-870-A	302-B	961	W-311-A W-312-A
8.2 — 12.4	X-870-A X-880-A	303-A	960	X-311-A X-312-A
12.4 — 18.0	P-870-A P-880-A	314-A	959	Y-311-A Y-312-A
18.0 — 26.5	K-870-A K-880-A	313-A	958	K-312-B
26.5 — 40.0	R-870-A R-880-A	312-A	V-957	U-312-B
33.0 — 50.0			Q-957	Q-312-B
50.0 — 75.0		323	M-957	M-312-B
60.0 — 90.0			E-957	E-312-B

* See Code of Manufacturers, Table 15

TABLE 11: BOLOMETER MOUNTS

COAXIAL BOLOMETER MOUNTS			
Frequency Range (GC)	Manufacturer*	Model Number	Barretter Model Number
0.01 — 10	Weinschel	926[1]	943

WAVEGUIDE BOLOMETER MOUNTS					
Frequency Range (GC)	Manufacturer's* Model Number				
	FXR	H-P	Narda	PRD	Sperry
2.60 — 3.95	S-207A	S-485A	534	S6608	33S2
3.95 — 5.85	H-207A	G-485A	533	G6608	33C2
5.85 — 8.20	C-207A	J-485A	532	C6608	33G2
7.05 — 10.00	W-207A	H-485A	531	H6608	33H2
8.20 — 12.40	X-207A	X-485A	530	X6608	33X2
12.4 — 18.0	Y-205		529	620	
18.0 — 26.5	K-205			620F1	
26.5 — 40.0	U-205			618F1	
33.0 — 50.0	Q-206				
50.0 — 75.0	M-206				
60.0 — 90.0	E-206				

*See Code of Manufacturers, Table 15.

[1] This unit has a built-in noise suppressor equivalent to Weinschel Model 936N. It is fixed tuned and has a VSWR below 1.5 over the entire frequency range

TABLE 12: BARRETTERS

Type	Description	DC Bias (MA)	Manufacturer's* Model Number					Special Features
			Weinschel	FXR	Narda	PRD	Sperry	
1	1N21	4.5		Z-220-C	N-610-B-4.5	610A		
2	1N21	8.75		Z-220-A	N-610-B		38B7	
2	1N21	8.25		Z-220-B				
3	1N21	8.75			N-610-B-100			100 ohms
4	.193" dia. .812" long	8.75			N-821-B		38B1	
5	1N26	4.5				614		12.4-26.5 GC
5	1N26	8.75		Z-221-A				12.4-40 GC
6	Modified	8.75		Z-221-B				26.5-40 GC
7	1N53	8.75		Z-222-A				26.5-90 GC
8	Special Mica Strip	4.5			N-603-4.5	631-C		0.5-10 GC
9	"	8.75			N-603			0.5-10 GC
10	"	4.5				617		18-40 GC
11	Miniature	8.75			N-604			8.2-18 GC (Low Inductance)
12	1N21	8.75			N-605			1.1-10 GC
13	Special Disc		943					.01-10 GC Coax.

*See Code of Manufacturers, Table 15.

TABLE 13: DIRECTIONAL COUPLERS

COAXIAL		
Frequency Range (GC)	**Manufacturer***	**Model Number**
225 — 460	Narda	3000-10
460 - 950	Narda	3001-10
950 — 2 0	Narda	3002-10
2 0 — 4 0	Narda	3003-10
4 0 — 8 0	Narda	3044-10
7 0 — 11 0	Narda	3045-10

WAVEGUIDE					
Frequency Range (GC)	**Manufacturer's* Model Number**				
	H-P	**FXR**	**PRD**	**Narda**	**Sperry**
2 6 — 3 95	S752C	S610C	409	1074-10	45S1
3 95 -- 5 85	G752C	H610C	410	1073-10	45C1
5 85 -- 8 2	J752C	C610C	411	1072-10	45G1
7 05 — 10 0	H752C	W610C	412	1071-10	45H1
8 2 — 12 4	X752C	X610C	408	1070-10	45X1
12 4 — 18 0	P752C	Y610C	413	1069-10	45U1
18 0 — 26 5	K752C	K610C		1068-10	45K1
26 4 — 40 0	R752C	U610C		V1067-10	45VI
50 0 — 75 0		M610C		M1067-10	

*See Code of Manufacturers, Table 15.

TABLE 14: DETECTOR MOUNTS

COAXIAL		
Frequency Range (GC)	**Manufacturer* and Model Number**	**Crystal Type**
0 01 — 10	H-P, Model 420A	Modified 1N26
0 01 - 1 0	PRD, Model 641	Sylvania 1N21
0 5 - 1 0	Am. Elect. Lab., Model C1000	Micro Assoc. MA408
1 0 — 10 0		
1 0 — 10 0	Weinschel, Model 578	Micro Assoc. MA408

WAVEGUIDE										
Frequency Range (GC)	**Manufacturer*, Model Number and Crystal Type**									
	Aircom	**Crystal Type****	**PRD**	**Crystal Type****	**Micro Assoc**	**Crystal Type****	**FXR**	**Crystal Type****	**H-P**	**Crystal Type****
3 95 — 5 85	157-C	1N23								
5 85 - 8 2	157-XC	1N23								
8 2 — 12 4	157-X	1N23			536C	1N23	X211A	1N23	X421A	1N26 (mod.
12 4 — 18 0	157-KU	1N76	616A	1N76			Y205B	1N26	P421A	1N26 (mod.
18 0 — 26 5	157-K	1N26	621	1N26	1039C	1N26	K205B	1N26		
26 5 — 40 0	157-KA	1N53			513E	1N53	U206B	1N53		
33 0 - 50 0	157-V	1N53					Q206B	1N53		
50 0 - 75 0	157-W	1N53			669	1N53	M206B	1N53		

*See Code of Manufacturers, Table 15
**Sylvania Model Number listed.

TABLE 15: CODE OF MANUFACTURERS*

Abbreviation	Manufacturer's Name and Address
Aircom	Aircom, Inc. 48 Cummington Street Boston, Mass.
Airtron	Airtron Division of Litton Industries 200 East Hanover Avenue Morris Plains, N. J
Alford	Alford Manufacturing Company 299 Atlantic Ave Boston, Mass
Am. Elect. Lab.	American Electronics Lab., Inc. 121 North 7th Street Philadelphia 6, Pa
Bird	Bird Electronics Corp 30303 Aurora Road Cleveland 39, Ohio
BJ Electronics	BJ Electronics, Division of Borg-Warner Corp. 3300 Newport Boulevard Santa Anna, Calif.
Cascade	Cascade Research Division, Lewis & Kaufman Electronics Corp. 5245 San Fernando Road, W. Los Angeles, Calif.
FXR	FXR, Division of Amphenol Borg Electronics Corp. 33 E. Franklin Street Danbury, Conn
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, Calif.
Kearfott	Kearfott Division, General Precision, Inc. 14844 Oxnard Street Van Nuys, Calif.
Micro Assoc.	Microwave Associates, Inc. Northwest Industrial Park Burlington, Mass.
Micromega	Micromega Corp. 4134 Del Rey Avenue Venice, Calif.
Narda	Narda Microwave Corp. Plainview, N. Y.
PRD	PRD Electronics 202 Tillary Street Brooklyn, N. Y.
Rantec	Rantec Corp. Craftsman Center Calabasas, Calif.
Raytheon	Raytheon Co. Microwave and Power Tube Division Foundry Avenue Waltham 54, Mass.
Sierra	Sierra Electronics Corp., Division of Philco Corp. 3885 E. Bohannon Drive Menlo Park, Calif.
Sperry	Sperry Microwave Electronics Co., Division of Sperry Rand Corp. P.O. Box 1828 Clearwater, Florida
TRG	TRG Inc. 2 Aerial Way Syosset, N. Y.
Varian	Varian Associates 611 Hansen Way Palo Alto, Calif.

* This list does not constitute an endorsement

APPLICATION NOTE NO. 4

WEINSCHEL ACCESSORIES

Weinschel Engineering produces a complete line of precision accessories for use with the Dual Channel Insertion Loss Test Set that has been described in the Application Note. Included among these accessories are both coaxial and waveguide noise suppressors, coaxial double stub tuners, bolometer mounts, and fixed and variable coaxial attenuators.

All Weinschel instruments and accessories are designed and manufactured to meet the most exacting requirements. Your assurance of quality and precision is a three-step inspection program. All purchased components and materials are inspected as they are received at Weinschel, and all instruments and components are inspected during various stages of manufacture. Completed items must then pass a rigid final inspection which is followed by careful calibration on the most precise measurement instrument available.

For the utmost in reliability and precision, a complete system of Weinschel instruments and accessories is unsurpassed.

We invite you to write for complete specifications on Weinschel precision accessories.

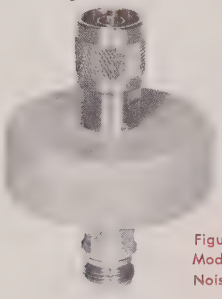


Figure Number 10:
Model 936N, Coaxial
Noise Suppressor

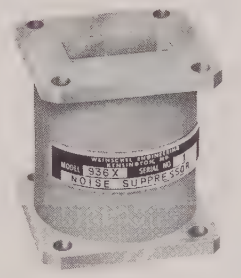


Figure Number 11:
Model 936X, Waveguide
Noise Suppressor

Figure Number 12:
Model DS109,
Double Stub Tuner

WEINSCHEL ENGINEERING

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APPENDIX II

SPECIFICATION FOR WEINSCHEL VM-1D STANDARD ATTENUATOR COMPARATOR

IM #54

September 1963

MODEL VM-1D STANDARD ATTENUATOR COMPARATOR

(Patents # RE 25,396, 3,098,968, and 3,104,354)

This instrument is useful for the measurement of any R.F. quantity which can be reduced to a power ratio or voltage ratio measurement. One major use is the CALIBRATION OF OUTPUT ATTENUATORS OF SIGNAL GENERATORS. Other uses are the measurement of coupling and directivity of directional couplers, the calibration of microwave receivers, the measurement of insertion LOSS of microwave FILTERS both in the pass band as well as in the STOP BAND, the measurement of antenna patterns and the measurement of high VSWR, and of high insertion losses.

Features:

SENSITIVE TO -120 DBM (3 db bandwidth is about 700 kc)

Accuracy between -21 and -81 dbm exceeds .02 db/10 db.

Direct reading, easy-to-use. After initial set-up at a fixed frequency, a semi-skilled operator can calibrate eight 10 db steps of signal generator output attenuator in about three minutes. COMPENSATES FOR FREQUENCY DRIFT OF R.F. SOURCE by A.F.F. control of local oscillator.

Description:

The Model VM-1D Standard Attenuator Comparator, which is a radio frequency heterodyne ratio meter, uses a PARALLEL SUBSTITUTION technique. The 30 mc output of a very linear mixer produced by the unknown R.F. voltage is compared with the reference voltage generated by a crystal-controlled, 30 mc standard source.

The level of the reference signal is set to equality with the level of the mixer output by means of a precision piston attenuator which is the heart of the equipment. The piston attenuator at 30 mc has a design accuracy of .01 db for a range of 70 db and of .02 db for a range of 92 db. The VM-1D incorporates the use of a direct reading optical system which permits measurements to be made even more quickly than earlier models. Refer to Page 4 for a full description of the optical readout system.

The control unit of the VM-1D is mounted upon an aluminum table which also houses modulators, i.f. amplifiers, A.G.C. and A.F.F chasses, linear and coherent detectors and power supplies as well as the precision piston attenuator with the 30 mc reference source. To facilitate movement, the table is set on large casters that can be locked to hold the equipment stationary.

The equipment is supplied as a WORKING SYSTEM with local oscillators and mixers; it is installed by factory personnel and the customer's operator is instructed in the operation by a Weinschel engineer on the customer's premises.

Weinschel Engineering
Gaithersburg, Maryland

Specifications:

Frequency Range: By selection of the proper Weinschel mixers, signal sources, and local oscillators, the following frequency range can be covered:
100 mc to 10,000 mc in coax.
8200 mc to 12,400 mc in X-band waveguide.

Voltage Range: 40 millivolts to 1 microvolt corresponding to power levels of -15 dbm to -107 dbm in a 50 ohm system. Since voltage measurements are rather difficult above 1,000 mc, levels preferably should be specified in power.

Attenuation Range: 92 db in one step at levels indicated above. Since many signal sources produce a 100 milliwatt average output, an additional 35 db can be measured by partial rf substitution with the substituted rf attenuator calibrated on the same set-up, while supervising the incident power level in order to simulate operation from a matched source. This extends the range to 127 db as long as the proper isolation exists between the higher power source and the measuring equipment.

Accuracy:

Voltage in 50-ohm system	Power level	Accuracy
40 mv - 20 mv	-15 dbm to -21 dbm	.1 db/10 db
20 mv - 20 μv	-21 dbm to -81 dbm	.02 db/10 db
20 μv - 1 μv	-81 dbm to -107 dbm	.1 db/10 db*
1 μv - .2 μv	-107 dbm to -121 dbm	.2 db/10 db*

Precision: (Due to sensitivity, stability)

Voltage in 50-ohm system	Power level	Precision
40 mv - 10 μv	-15 dbm to -87 dbm	± .01 db to ± .02 db
10 μv - 1 μv	-87 dbm to -107 dbm	± .02 db to ± .1 db
at .2 μv	-121 dbm	± .2 db

This assumes the use of a stable rf source having less than 50 kc incidental F.M. and stable repeatable rf connections.

Sensitivity of Amplitude Balance Indication:

.05 db will produce full scale (10 divisions) deflection on the zero center meter at signal levels between 40 mv and 10 μv. At signal levels between

*These accuracies are obtainable if the signal source is modulated. If the local oscillator is modulated, a systematic error is introduced and can be corrected for.

10 μv and 1 μv, .25 db will produce the same deflection. These are typical sensitivities, which are adjustable and can be increased beyond these values.

Notes on Stability:

For maximum stability, the equipment should be operated under conditions of constant supply voltage, constant ambient temperature and reasonably quiet acoustic environment. A one-hour warm up time is required before the full precision of the equipment is realized. All Weinschel Accessory rf sources have a stability of better than ± .02 db/minute and ± .1 db/hour for a constant load.

Sensitivity of Frequency Difference Indication: (Over ± 10 divisions)

20 kcs difference will produce full scale deflection on the zero center meter independent of voltage level from 40 millivolts to 10 microvolts.

These are typical sensitivities. Sensitivity can be adjusted.

I.F. Amplifier Response:

In a 100 kc band centered at 30 mc the slope of the response characteristic is less than .001 db per kc at all points. The bandwidth between 3 db points is approximately 700 kc.

Stability of Mixer Conversion Loss with Change of Local Oscillator Voltage:

For any change of indicated crystal current between 0.65 ma and 0.85 ma the deviation of the i.f. output level is less than 0.01 db, (for a constant rf input and a sufficiently decoupled local oscillator).

Local Oscillator Requirement:

(a)	Power Required:	50 mW ave. into 50 ohm load.
(b)	Frequency Stability:	5 kcs per 2 minutes (up to 1,000 mc) for local oscillators not using A.F.F.
(c)	Modulation:	Capable of being 100% modulated by an external 1000 cps square wave.
(d)	A.F.F. Circuits:	To compensate automatically for drift of frequency of rf source over a range of ± 1/2% above 900 mc with in 5 kcs.
(e)	Incidental F.M.:	Less than 50 kc peak-to-peak.

Model VM-1D System with associated instrumentation for operation from 50 mc to 10,000 mc in 50 ohm coax.

(1)	Basic Model VM-1D Standard Attenuator Comparator	$27,500.00
	(Installation and one-week instruction period)	1,500.00
	Mixers:	
(1)	Model 1002-E (50-100 mc)	450.00
(1)	Model 1002-A (100-4000 mc)	included in price of basic VM-1D

(1)	Model 1002-C (4000-8000 mc)	500.00
(1)	Model 1002-D (8000-10,000 mc)	550.00
	Local Oscillators:	
(1)	Model MS-12 (50-250 mc)	625.00
(1)	Model MS-13 (250-920 mc)	750.00
(1)	Model MS-8 (900-2200 mc)	1,550.00
(1)	Model MS-9 (2100-4200 mc)	1,500.00
(1)	Model MS-10 (4000-7300 mc)	1,800.00
(1)	Model MO-5 Modulator-Power Supply	2,400.00
(1)	Model MS-30 (7500 mc-10,000 mc)	2,320.00
(1)	Model MO-4 Modulator-Power Supply	2,000.00
(1)	Model KC-1 Klystron Cooling Control	1,400.00
	RF Signal Sources:	
(1)	Model MS-12 (50-250 mc)	625.00
(1)	Model MS-13 (250-920 mc)	750.00
(1)	Model MS-8 (900-2200 mc)	1,550.00
(1)	Model MS-9 (2100-4200 mc)	1,500.00
(1)	Model MS-10 (4000-7300 mc)	1,800.00
(1)	Model MO-5 Modulator-Power Supply	2,400.00
(1)	Model MS-30 (7500-10,000 mc)	2,320.00
(1)	Model MO-4 Modulator-Power Supply	2,000.00

Additional instrumentation required for VM-1D system operation in X and K_u bands waveguide.

	Mixer:	
(1)	Model 1002-X (8200-12,400 mc)	550.00
(1)	Model 1002-P (12.4-18.0 mc)	650.00
	Local Oscillator:	
(1)	Model MS-31 rf source components (8.2-12.4 mc)	1,790.00
(1)	Model MS-32 rf source components (12.4-18.0 mc)	2,350.00
	RF Signal Source:	
(1)	Model MS-31 rf source components (8.2-12.4 mc)	1,790.00
(1)	Model MS-32 rf source components (12.4-18.0 mc)	2,350.00

Optical Readout System:

Weinschel Engineering's Model VM-1D Standard Attenuator Comparator incorporates a direct reading optical system which permits measurements to be made more quickly than on earlier models. Since less time is required between the reference and attenuated signal readings, the accuracy of the measurement is generally improved.

The optical system measures the travel of the loop on the standard piston attenuator in the VM-1. No physical contact is required for the readout system, hence wear has been eliminated as a factor in the measurement.

The readout system consists of an 8-inch hardened stainless steel scale reading directly in db and an illuminated optical device with a 22 power lens system. The diameter of the waveguide below cut-off attenuator in the VM-1 provides 10 db of attenuation per .500 inch of travel and so the 8-inch scale on the optical readout covers a range of 160 db with a resolution of 0.002 db.

The scale is rigidly mounted to the 30 mc standard source case which is an integral part of the movable piston. The optical device is rigidly mounted to the base casting of the piston attenuator assembly. The entire measuring system can be easily removed for checking in a gage laboratory.

The scale is marked directly in db and has a division every 0.025 inch, corresponding to 0.50 db. The position of these divisions is accurate to ± .0002 inch from the "0" mark (at 68°F). Thus, the maximum possible inaccuracy between any two divisions may be ± .0004 inch which is equivalent to .008 db.

The optical device consists of a double line Archimedes spiral reticle. When the position is adjusted so that the double lines bracket a division of the scale, a direct readout is obtained over a range of 0.50 db with a resolution of .002 db per division (equivalent to .0001 inch).

The deviation from true concentricity between the dial and the Archimedes spiral could cause a variation of 0.0001 inch from the scale reference mark to the reading. The maximum possible inaccuracy of the combined scale and optical device is ± .0005 inch, which is equal to ± 0.01 db for the entire 160 db range of the scale.

The coefficient of expansion of the scale is 5.7×10^{-6} per degree F. The coefficient of expansion of the critical I.D. of the piston attenuator, however, is about 10×10^{-6} per degree F. This over-compensates the scale expansion and leaves an effective net expansion of minus 4×10^{-6} per degree F. For a 100 db measurement at 78°F instead of 68°F, the error is only -.004 db. For smaller db steps or temperature differentials, the error is reduced in direct proportion.

Recommended Accessory for Absolute Calibration of Signal Generator Output:

Precision thermistor power bridge, Model TB-2A and calibrated thermistor mount, Model 675A in coax and the Models 811T, 813T, 815T X-band power standards. This bridge operates at a fixed level of one milliwatt. The accuracy of the substituted dc power is 0.15% at this level. The "calibration factor" for the thermistor mount should be known at the frequency of interest.

Dimensions: Control Unit -- 36" wide, 20" high, 12-1/4" deep.
Piston Attenuator Table -- 48" wide, 37" high, 19" deep.

Weight: Approximately 700 lbs.

Price: Information upon request; includes installation and one week training in your laboratory.

Delivery: Information upon request.

Operation and Maintenance Manual for Basic System:

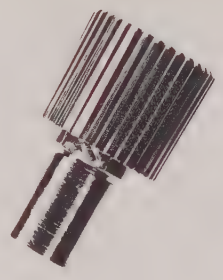
About 80 pages of text, 43 pages of parts list, 15 schematics; 1 copy furnished with equipment.

NEW PRODUCT DATA

PRECISION BROADBAND COAXIAL TERMINATIONS

SERIES 1403

DC TO 18 GHZ



Model 1403 GPA
(actual size)

Represented By:
JAY STONE AND ASSOCIATES
140 Main Street
Los Altos, Calif.
Telephone: 948-4563

FEATURES

- BROADBAND - DC to 18 GHz.
- STABILITY - film resistors are artificially aged for long term stability and maximum stability under pulse power.
- CALIBRATION - Individual VSWR calibrations supplied at seven frequencies: DC, 1, 4, 8, 10, 12.4 and 18 GHz.
- CONNECTORS - Choice of stainless steel Type N male, Type N female, or precision 7 mm connectors.

APPLICATIONS

The Series 1403 Terminations broaden the range of applications for coaxial systems, including use of the 12.4 to 18 GHz band usually reserved for waveguide. terminations can be used for numerous applications in the laboratory and in equipments or systems where a low reflector coaxial load is required. These applications include use as reference loads, dummy antennas, terminations on components and lines for SWR measurements.

DESIGNERS AND MANUFACTURERS OF PRECISION MICROWAVE EQUIPMENT

WEINSCHEL ENGINEERING

GAITHERSBURG, MARYLAND • TEL: (301) 948-3434 • TWX: 301-926-3730

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DESCRIPTION

The Ⓔ Series 1403 Terminations are the first terminations covering the entire frequency range from DC to 18 GHz and are exceptionally well matched, compact 50 ohm coaxial low power loads. They are made with special Ⓔ film resistors which give maximum stability under peak pulse power and are capable of withstanding moderate short overloads without permanent damage.

Ⓔ Model 1403N features Ⓔ Precision stainless steel male or female Type N connectors (Ⓔ Model 1518). These connectors are machined to the tightest practicable tolerances on both the body and support bead; their VSWR is considerably lower than that of any other commercially available Type N connectors.

Ⓔ Models 1403 GPA and 1403 GPR feature 7 mm General Precision Connectors, Amphenol No. 131-1051, and Rohde & Schwarz No. FNA-1347/50, respectively.

SPECIFICATIONS

FREQUENCY RANGE: DC to 18 GHz

MAXIMUM POWER INPUT: 1 watt average, 1 kW peak; (5 μsec pulse length)

MAXIMUM VSWR: Measured on slotted lines. Specifications apply for power input not exceeding 100 mW average.

METHOD OF VSWR MEASUREMENT: Directly on tuned slotted line

DC RESISTANCE: 50 ohms ±1 ohm at 25°C

TEMPERATURE COEFFICIENT OF RESISTOR: 0.03%/°C

CALIBRATION DATA SUPPLIED: DC resistance accurate to 0.25%

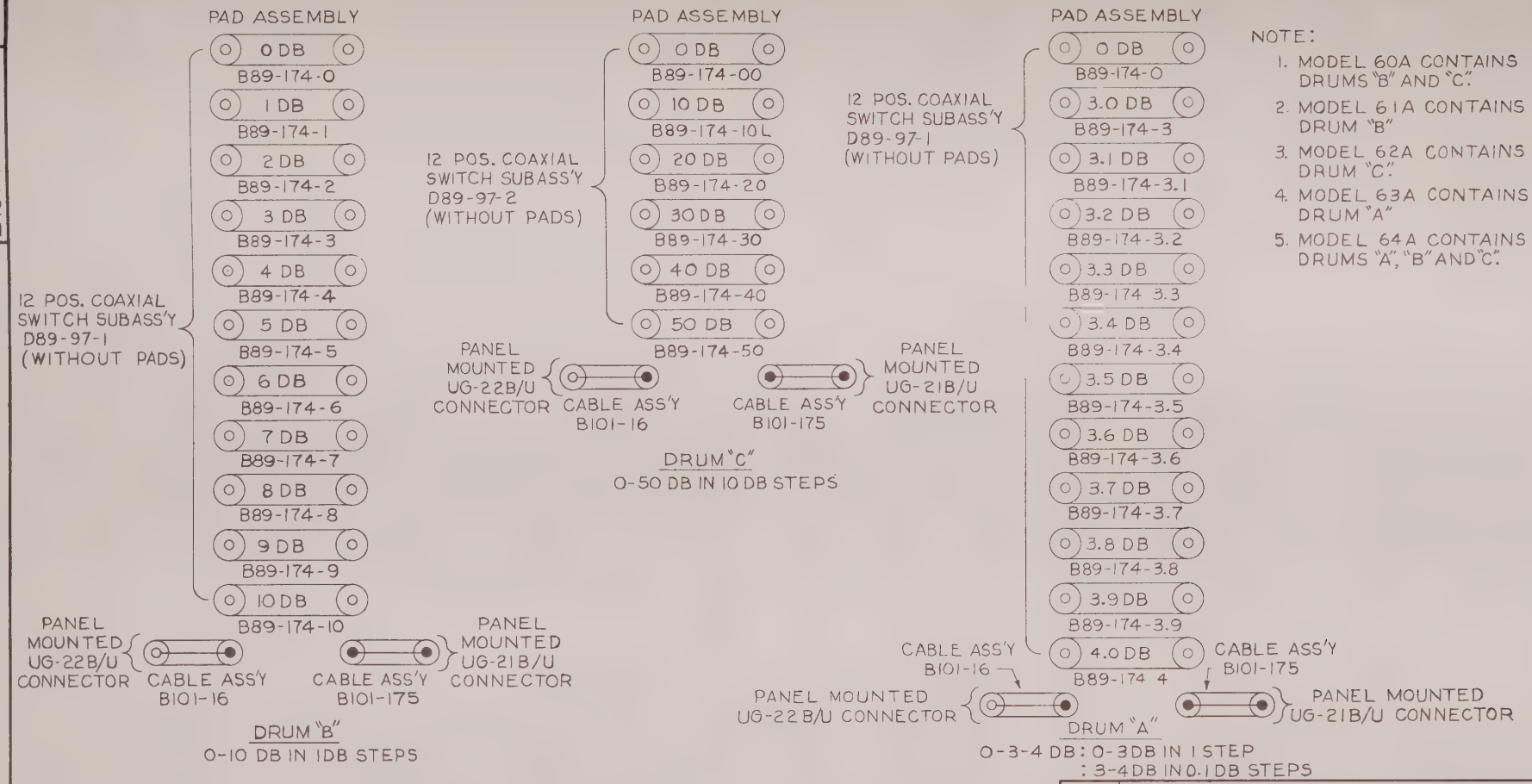
VSWR at 1 GHz accurate to 2%
VSWR at 4 GHz accurate to 3%
VSWR at 8 and 10 GHz accurate to 5%
VSWR at 12.4 GHz and 18 GHz accurate to 5%

MODEL NO.	CONNECTOR	TO MATE WITH	MAXIMUM VSWR IN 50 OHM SYSTEM	DIMENSIONS		WEIGHT		PRICE
				LENGTH	DIAMETER	NET	SHIPPING	
F1403N	Precision Type N Female	Type N Male	1.04 max. to 4 GHz 1.05 max. to 12.4 GHz 1.07 max. to 18 GHz	1.75"	.625"	1.4 oz.	14 oz.	$85
M1403N	Precision Type N Male	Type N Female	1.04 max. to 4 GHz 1.05 max. to 12.4 GHz 1.07 max. to 18 GHz	1.7"	.8"	1.6 oz.	14 oz.	$85
1403 GPA	7 mm Amphenol	GPC-7	1.03 max. to 4 GHz 1.04 max. to 12.4 GHz 1.05 max. to 18 GHz	1.375"	.82"	1.3 oz.	14 oz.	$85
1403 GPR	7 mm Rohde & Schwarz	Precifix A	1.03 max. to 4 GHz 1.04 max. to 12.4 GHz 1.05 max. to 18 GHz	1.375"	.8"	1.2 oz.	14 oz.	$100

CALIBRATION AT ADDITIONAL FREQUENCIES: $3.50 per frequency

TERMS: Prices and specifications are subject to change without notice. Terms are net 30 days, subject to approval of credit. All prices are F.O.B. Gaithersburg, Maryland and include commercial inspection and packing for domestic shipment to continental United States.

B101-174



NOTE:

1. MODEL 60A CONTAINS DRUMS "B" AND "C".
2. MODEL 61A CONTAINS DRUM "B"
3. MODEL 62A CONTAINS DRUM "C".
4. MODEL 63A CONTAINS DRUM "A"
5. MODEL 64A CONTAINS DRUMS "A", "B" AND "C".

REVISIONS

USED ON	ASSY. DRWG.
60A	
61A	
62A	
63A	
64A	

DIMENSIONS ARE IN INCHES
TOLERANCES
All 3 Place Decimal Dims. ±.003
All 2 Place Decimal Dims. ±.01
All Fractional Dims. ±1/64
All Angles ± 1/2°
Unless Otherwise Specified

Weinschel Engineering
Kensington, Maryland
©1962

SCHEMATIC DIAGRAM

MATERIAL

FINISH

DFDL 2-28-62	C 10/2/63	SCALE
E 10-2-63	A 10/2/63	B101-174

SECTION II

INITIAL PREPARATION FOR USE

2.1 UNPACKING INSTRUMENT

The Precision Stepattenuator is shipped in a double carton with three inches of packing material between the inner and outer carton. Exercise normal care when removing the instrument and packing material; the only additional item is this Instruction Manual. Examine the instrument for physical damage.

NOTE

Do not remove the attenuator shields unless they show signs of damage.

Notify the shipping company immediately if evidence of damage is found; if shipped FOB Gaithersburg, Maryland, damage claims must be collected by the consignee. Do not destroy the shipping cartons or packing material until an agent of the shipping company has examined them; do not return the instrument to Weinschel Engineering until a claim for damage has been established.

2.2 SPECIAL CAUTIONS

The following cautions must be observed when operating the Precision Stepattenuator:

a. Rotate LOCK knob fully counterclockwise before moving main dial.
b. Rotate main dial to its final position before engaging coaxial switches by rotating LOCK knob fully clockwise.
c. Properly terminate Stepattenuators before applying power.
d. To insure calibrated accuracy, never apply more than 2.2 volts rms to the input of the Stepattenuator while its output is properly terminated.
e. To insure calibrated accuracy, never exceed 100 mw average power input. If necessary, use external attenuation to reduce input power level to 100 mw average.

SECTION III

OPERATING INSTRUCTIONS

3.1 CONNECTIONS

The Precision Stepattenuator does not require preliminary adjustment, alignment, or warm-up time. Certain cautions (paragraph 2.2) must be observed when operating the instrument.

Power input and output connections are made with coaxial cables fitted with type UG-21B/U and UG-23B/U coaxial connectors. The attenuator groups can be connected in series by about 12 inches of RG-9/U coaxial cable (not furnished) terminated with one type UG-21B/U connector and one type UG-23B/U connector. In the case of the Model 60A and 64A, aluminum jacketed cables are furnished to facilitate cascading of switches.

3.2 IMPEDANCE MATCHING

When the Stepattenuator is used in power or insertion loss measurement systems, the external load connected to the Stepattenuator should be 50 ohms. Loads other than 50 ohms will cause an impedance mismatch and some of the power to the load will be reflected rather than absorbed; this mismatch produces standing waves. Double stub tuners, which act as variable rf impedance transformers and permit the standing-wave ratio to be minimized, can be used to match wide ranges of impedance. Impedance matching is important during power or attenuation measurements since the assumption usually made is that the incident power is being measured. This assumption is correct only if all of the incident power is absorbed by the power-measuring element.

One factor which is often overlooked and which contributes error in high frequency measurements is the assembly of the coaxial cable to the connector. Improper assembly can cause a high standing-wave ratio with attendant error.

3.3 OPERATING PROCEDURE

To insert selected amount of attenuation proceed as follows:

a. Rotate appropriate LOCK knob fully counterclockwise.
b. Rotate corresponding main dial (upper knob) to final desired attenuation.

CAUTION

Never rotate the main dial unless the LOCK knob is fully counterclockwise. Failure to observe this procedure may damage the coaxial switch.

c. Rotate LOCK knob below main dial fully clockwise.
d. Selected amount of attenuation is now inserted.

SECTION IV

MAINTENANCE

4.1 GENERAL

The Precision Stepattenuator incorporates design advances that insure long trouble-free operation with a minimum of maintenance. However, if the compliance tests (Section V) reveal faulty instrument performance, the trouble may be localized by reference to Table 4.1.

NOTE

If any component of the Stepattenuator is replaced, the entire Compliance Test Procedure (Section V) must be performed.

4.2 REPLACEMENT OF INDIVIDUAL ATTENUATOR ASSEMBLIES

a. Remove shield from drum assembly.
b. Rotate drum assembly until defective attenuator assembly is in accessible position.
c. Remove snap ring on end of defective pad (Waldes-Kohinoor Co. Standard Pliers No. 2 or equivalent).
d. Remove defective attenuator assembly.
e. Insert replacement.
f. Replace snap-ring on replacement attenuator assembly.
g. Replace shield on drum assembly.
h. Perform Compliance Tests (Section V).

4.3 LUBRICATION

The coaxial switches, which are the only items requiring lubrication, may be expected to give at least 10,000 trouble-free switching operations. After 2,000 operations, the sliding surfaces of the switch box and the wearing surfaces of the worm gear, detent assembly, and detent rollers should be lubricated with No. 8 Lubriplate supplied by Fiske Brothers Refining Co., Newark, New Jersey.

CAUTION

Do not lubricate the switch contacts.

TABLE 4.1

TROUBLESHOOTING

Symptom	Probable Cause	Remedy
Open circuit between input and output connectors on all main dial positions.	1. Coaxial switch not engaged. 2. Open cable between connector and switch. 3. Switch contacts fail to mate.	1. Rotate LOCK knob fully clockwise. 2. Check cable for continuity. If faulty, replace. 3. Replace coaxial switch assembly.
Intermittence between input and output connectors.	1. Coaxial connectors of switch not mating properly due to excessive wear of coaxial switch. 2. Intermittently open cable between connectors and switch.	1. Replace coaxial switch assembly. 2. Check cable for intermittent continuity. If faulty, replace.
Open circuit between input and output connector for individual position of main dial.	1. Coaxial switch not engaged. 2. Individual attenuator assembly open.	1. Rotate LOCK knob fully clockwise. 2. Replace individual attenuator assembly.
Attenuation not value indicated by main dial.	Attenuator assembly of indicated value damaged by overload.	Replace attenuator assembly of value indicated by main dial.
High VSWR	1. Excessive wear of coaxial connectors in coaxial switch. 2. Attenuator assembly damaged.	1. Replace cable assembly. 2. Replace attenuator assembly.

SECTION V

COMPLIANCE TESTS

5.1 GENERAL

These tests verify the compliance of the Precision Stepattenuator with the original electrical specifications (table 1.2) as guaranteed by the manufacturer at the time the instrument left the factory. If the instrument does not meet the specifications, the fault, determined from table 4.1, can be easily remedied.

Under normal operating conditions the Stepattenuator should be calibrated once every six months.

5.2 EQUIPMENT REQUIRED

The test equipment required is listed in table 5.1, the cables in table 5.2, and the adapters in table 5.3. Insertion Loss measurements may also be made using a Weinschel Dual Channel Insertion Loss Test Set. The procedures and equipment are given in the Weinschel Engineering Application Note No. 4 which is contained in Appendix I of this manual.

TABLE 5.1

TEST EQUIPMENT REQUIRED

Qty.	Nomenclature (Manufacturer)	Mfr's Model No.	Application	Range	Accuracy
1	Standard Attenuator Comparator (Weinschel)	VM-1D	Insertion Loss Measurement	100 mc - 12,400 mc 92-db Range	0.02 db/10 db 60-db Range
2	Modulated RF Source (Weinschel)	MS-13	RF Source	250 mc - 920 mc	± 1% (frequency)
1	Modulated RF Source (Weinschel)	MS-8	Local Oscillator	900 mc - 2000 mc	± 1% (frequency)
1	Modulated RF Source (Weinschel)	MS-3	RF Source	900 mc - 2000 mc	± 1% (frequency)
1	Power Supply-Modulator (Weinschel)	MO-3	Power Supply and Modulator for RF Sources		
2	Attenuator (Weinschel)	50-20	Attenuate RF Power	DC-3000 mc	

(Cont.)

TABLE 5.1 (Cont.)

Qty.	Nomenclature (Manufacturer)	Mfr's Model No.	Application	Range	Accuracy
3	Double-Stub Tuner (Weinschel)	DS-109L	Impedance Matching	0.4 kmc-4 kmc	
1	Coaxial Termination (Weinschel)	535-FN	50-Ohm Coaxial Termination	DC-10 kmc	
1	VSWR Indicator (Hewlett-Packard Co.)	415B	Measurement of Voltage Standing-Wave Ratios		
1	Slotted Line (Rollins Co.)	62	Measurement of Voltage Standing-Waves		
1	Battery (Rubicon)	2799	DC Voltage Source	6 Volts	
1	Battery (Rubicon)	2799-A	DC Voltage Source	2 Volts	
1	Battery (Eveready)	No. 6	DC Voltage Source	1.5 Volts	
1	Standard Cell (Eppley Lab.)	100	DC Voltage Standard	1.01900-1.01940 Volts	0.01%
4	Resistor, Standard (Leeds & Northrup)	1030-B	Fixed Standard Resistance	100 Ohms	0.005%
1	DC Potentiometer (Leeds & Northrup) (Rubicon)	K-2, K-3 2780	Variable Voltage Divider		0.015%
1	Galvanometer (Rubicon)	3402-H	Null Indicator	0.012 μA per div.	

TABLE 5.2

TEST CABLES REQUIRED

Cable No.	Cable Type	Connectors (Quantity)	Length
1	RG-9/U	UG-21B/U (Two)	3 feet
2	RG-58A/U	UG-88/U (Two)	3 feet
3	RG-58A/U	UG-88/U (Two)	3 feet
4	RG-9/U	UG-21B/U (One); UG-23B/U (One)	3 feet
5	RG-9/U	UG-21B/U (Two)	4 feet

TABLE 5.3

ADAPTERS REQUIRED

Qty.	Type	Description
1	UG-27B/U	Male-to-female type N right-angle bend

5.3 CALIBRATION SERVICE

Weinschel Engineering Co., Inc., equipped to provide calibration service, has developed instruments capable of producing the accuracy stated and uses these instruments in performing this service. There are three classes of calibration service: Class A, Class B, and Special.

The accuracy of this service is maintained by periodic checks of the entire test arrangement through the use of standard attenuators. A suitable calibration certificate is issued with each component calibrated.

5.3.1 CLASS A SERVICE. This accurate calibration of insertion loss is justified only in cases where a high degree of accuracy is required. In general, Class A calibrations are not justified for coaxial equipment above 2000 mc due to the inaccuracy of impedance measurements under these conditions.

Under this class, calibration of insertion loss to an accuracy of 0.01 db/5 db is provided on units mating with type N connectors. Other type connectors will decrease the accuracy by an amount dependent upon the type connector used.

This class of service is available for coaxial components with a low VSWR in the frequency range from 100 mc to 2000 mc, and in X-band for values of insertion loss up to 70 db.

5.3.2 CLASS B SERVICE. This class of service is available for those calibrations which do not require the precision of Class A service. The accuracy of this class of service is 0.05 db/5 db over a maximum range of 120 db for frequencies from 100 mc to 12,400 mc.

5.3.3 SPECIAL CALIBRATION SERVICE. In addition to Class A and Class B calibration services, Weinschel Engineering, as an accommodation, will perform special calibrations of coaxial and waveguide equipment. These services are generally limited to calibrations of insertion loss, attenuation, power output, and power or voltage division. Typical examples include the calibration of voltage divisions of L-pads used as voltage dividers with signal generators, calibration of directional couplers for both coupling and directivity, measurement of insertion loss and VSWR of rotary waveguide joints, determination of transfer characteristics of magic tees, and calibration of the output attenuators of signal generators.

5.4 MEASUREMENT OF VSWR

5.4.1 DESCRIPTION. The VSWR measurements can be performed with the equipment arrangement shown in figure 5.1. Prior to insertion of the Precision Stepattenuator into the line, the VSWR is minimized. The Stepattenuator is inserted and, starting with the 0-db step, the VSWR is measured for each step. The VSWR measurement for both connectors can be made at each position by reversing input and output cables. The maximum VSWR allowable is 1.15 from dc to 1000 mc, and 1.25 from 1000 mc to 2000 mc. If the VSWR of both the isolation attenuator and step being measured are less than 1.25:1, the error of the indicated VSWR of the step being measured will be less than 2.5 percent.

5.4.2 PROCEDURE.

a. Connect equipment as shown in figure 5.1 except omit Stepattenuator.
b. Apply primary and rf power. Proper indicator lamps must come on.
c. Adjust Double Stub Tuner No. 2 for minimum VSWR. VSWR to be less than 1.04.
d. Insert Precision Stepattenuator.
e. Measure VSWR of each drum position.

5.5 SWITCH REPEATABILITY

Repeatability may be measured simultaneously with the insertion loss measurements (paragraph 5.6) by locking and unlocking the drum repeatedly after the insertion loss has been made and the system is at null. The deviation from the measured insertion loss should not exceed 0.01 db.

5.6 MEASUREMENT OF INSERTION LOSS AT 1000 MC AND 2000 MC (See figure 5.2)

5.6.1 DESCRIPTION. The zero insertion loss of each drum in the zero position as well as the incremental insertion loss above zero loss can be measured accurately and conveniently using the Standard Attenuator Comparator Model VM-1D (Weinschel Engineering). The VM-1D, which contains a precision piston attenuator,

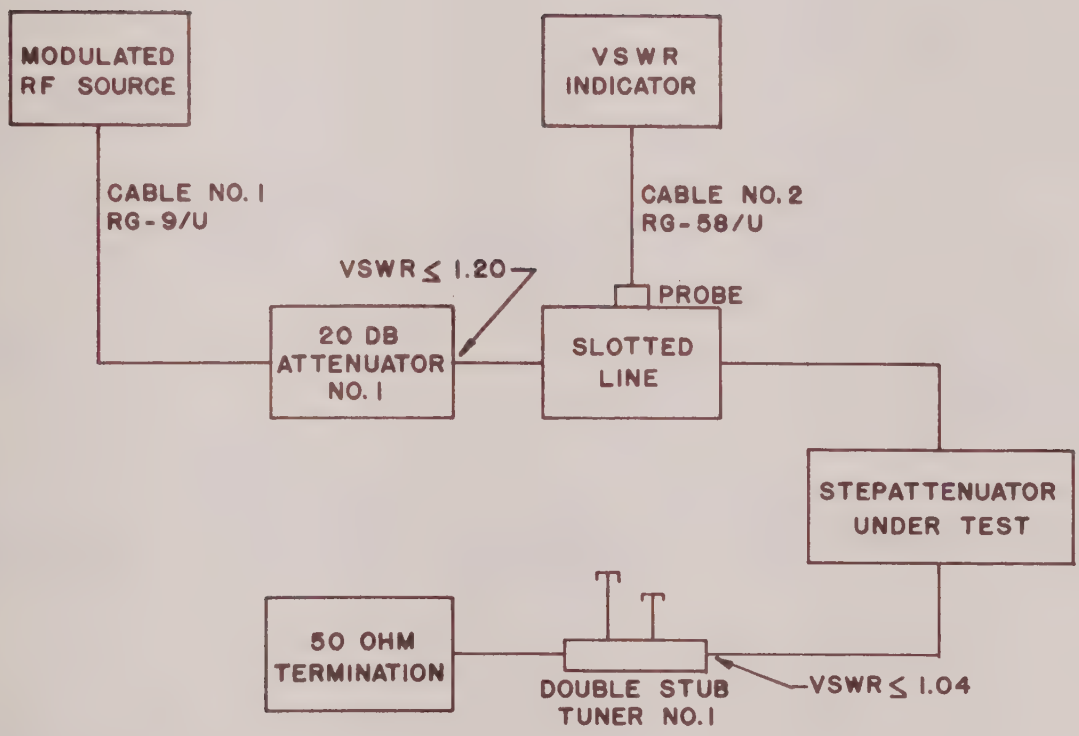


Figure 5.1 Equipment Interconnection for VSWR Test

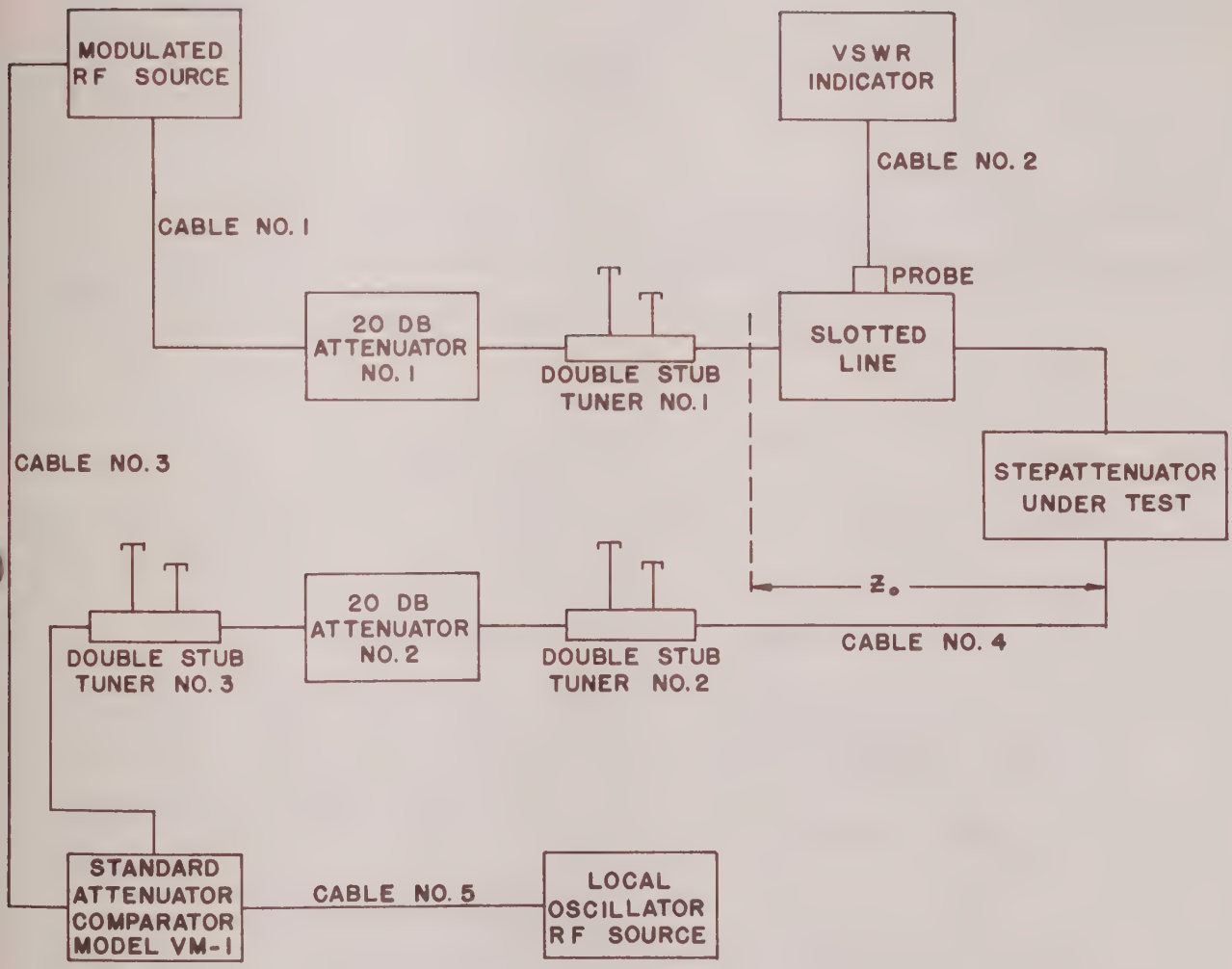


Figure 5.2 Equipment Interconnection for Insertion Loss Test

is capable of measuring 60 db (-21 dbm to -81 dbm) in one step with an accuracy of better than 0.02 db per 10 db. (Refer to the Appendix II of this Instruction Manual.) Two other advantages of this system are the elimination of rf substitution attenuators and the low rf power required for operation.

The insertion loss of the 0-db step is determined first. The insertion loss of each step is then determined by adding the incremental insertion loss of each step above the 0-db step to the insertion loss of the 0-db step. The Stepattenuator is always returned to the 0-db position after each measurement to insure that the rf power level or frequency has not changed. If a change has occurred,the measurement must be repeated.

5.6.2 PROCEDURE.

a. Connect equipment as shown in figure 5.2 except omit Stepattenuator.
b. Adjust VM-1D according to its Instruction Manual (IM #19).
c. When VM-1D is nulled for frequency and amplitude, record position of piston.
d. Insert Stepattenuator as shown in figure 5.2.

NOTE

Lock the drum of the Stepattenuator in the 0-db position.

e. Rotate vernier adjustment on VM-1D until amplitude is nulled.

NOTE

Move measuring device if necessary.

f. Record position of piston. The difference between this setting and the value obtained in step c is the insertion loss of the 0-db step.
g. Rotate drum of Stepattenuator to desired position. Lock it.
h. On VM-1D loosen locking screw on piston and move piston until amplitude null indicator approaches null.
i. Lock piston in place. Complete nulladjustment using vernier adjustment.
j. Move measuring device as required.
k. Record position of piston.
l. The difference in values obtained in step k and step f (or p) is the incremental insertion loss of the particular position of the Stepattenuator above the insertion loss of the 0-db step.
m. Add incremental insertion loss obtained in step l to insertion loss of 0-db step to obtain insertion loss of particular position of Stepattenuator.
n. Return Stepattenuator to 0-db position.
o. On VM-1D return measuring device to original position and adjust system for null.
p. Record position of piston.
q. Repeat steps g through p for each position of each drum of Stepattenuator.

5.7 MEASUREMENT OF DC INSERTION LOSS AND VOLTAGE DIVISION

5.7.1 DESCRIPTION. The insertion loss in a 50-ohm system (figure 5.3) is defined as the ratio of the power absorbed by a 50-ohm load from a 50-ohm generator before and after insertion of the unknown device between the generator and the load while the internal source voltage remains constant. The insertion loss, A, in decibels is

$$A = 10 \log_{10} \frac{P_1}{P_2}$$

where: P_1 = Power dissipated in the load before insertion of the device

P_2 = Power dissipated in the load after insertion of the device

Using voltage ratios, the insertion loss in decibels is obtained as follows:

$$P_1 = \frac{E_1^2}{R_o}$$

$$P_2 = \frac{E_2^2}{R_o}$$

where E_1 = Voltage across the load R_o before insertion of the device

E_2 = Voltage across the load R_o after insertion of the device.

Then:

$$A = 10 \log_{10} \frac{P_1}{P_2} = 10 \log_{10} \frac{E_1^2}{R_o} \cdot \frac{R_o}{E_2^2}$$

If R_o remains constant then

$$A = 10 \log_{10} \frac{E_1^2}{E_2^2}$$

which reduces to

$$\boxed{A = 20 \log_{10} \frac{E_1}{E_2}}$$

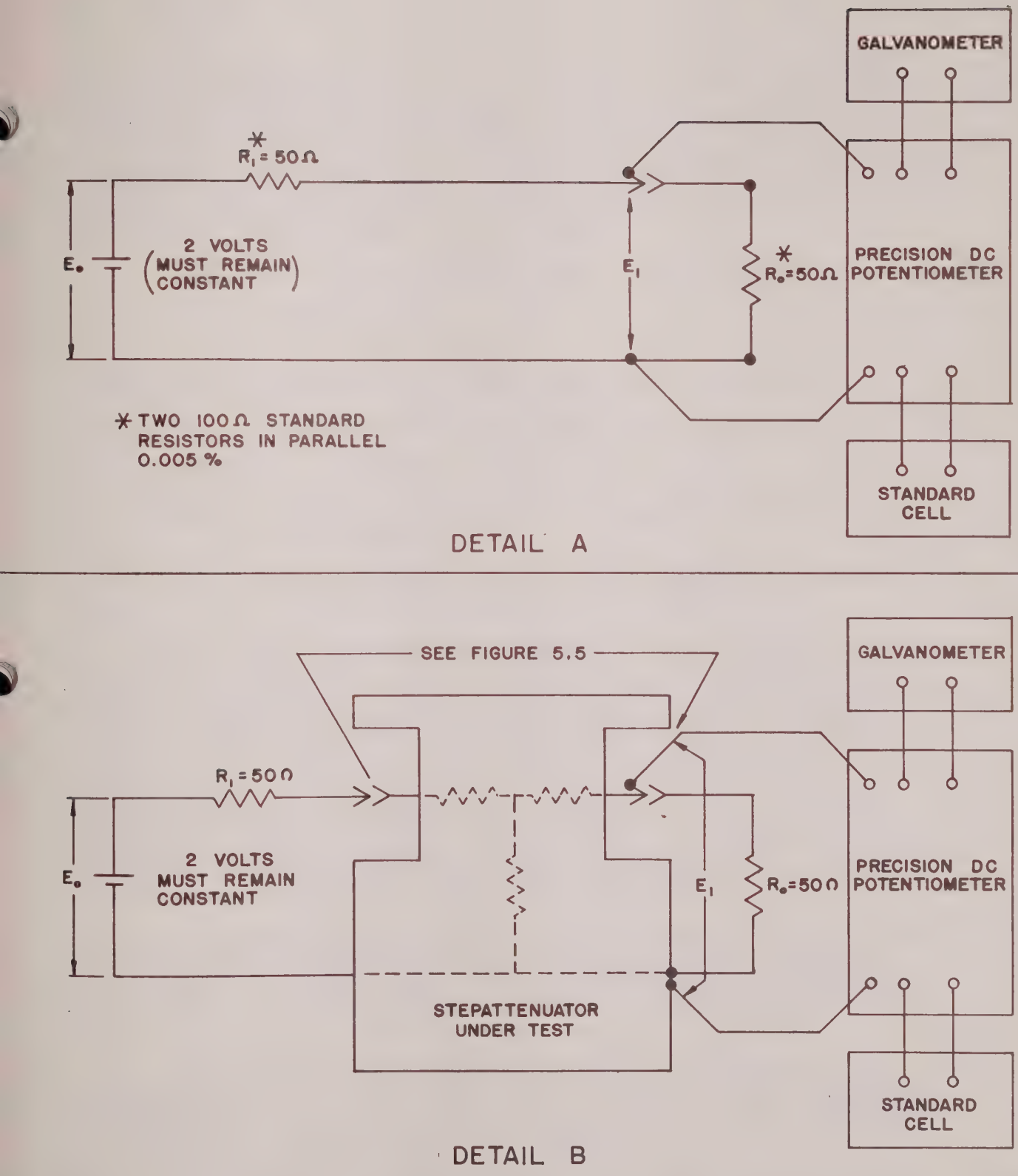


Figure 5.3 Equipment Interconnection for DC Insertion Loss Test

The voltage division ratio for a device is the ratio of the voltage across the input terminals to the voltage across the output terminals under specified conditions. An equivalent definition is the ratio of the voltage across the load when the load is connected across a constant voltage source to the voltage across the load when the unit under test (figure 5.4) is inserted between the constant voltage source and the load. Note that in an insertion loss measurement a 50-ohm source is specified whereas in a voltage division measurement a constant-voltage source is required.

The voltage division can be expressed in decibels as

$$V.D. = 20 \log_{10} \frac{E_1}{E_2}$$

where: E_1 = Voltage across input terminals of unit under test

E_2 = Voltage across output terminals of unit under test

If E_1 is derived from a constant voltage source

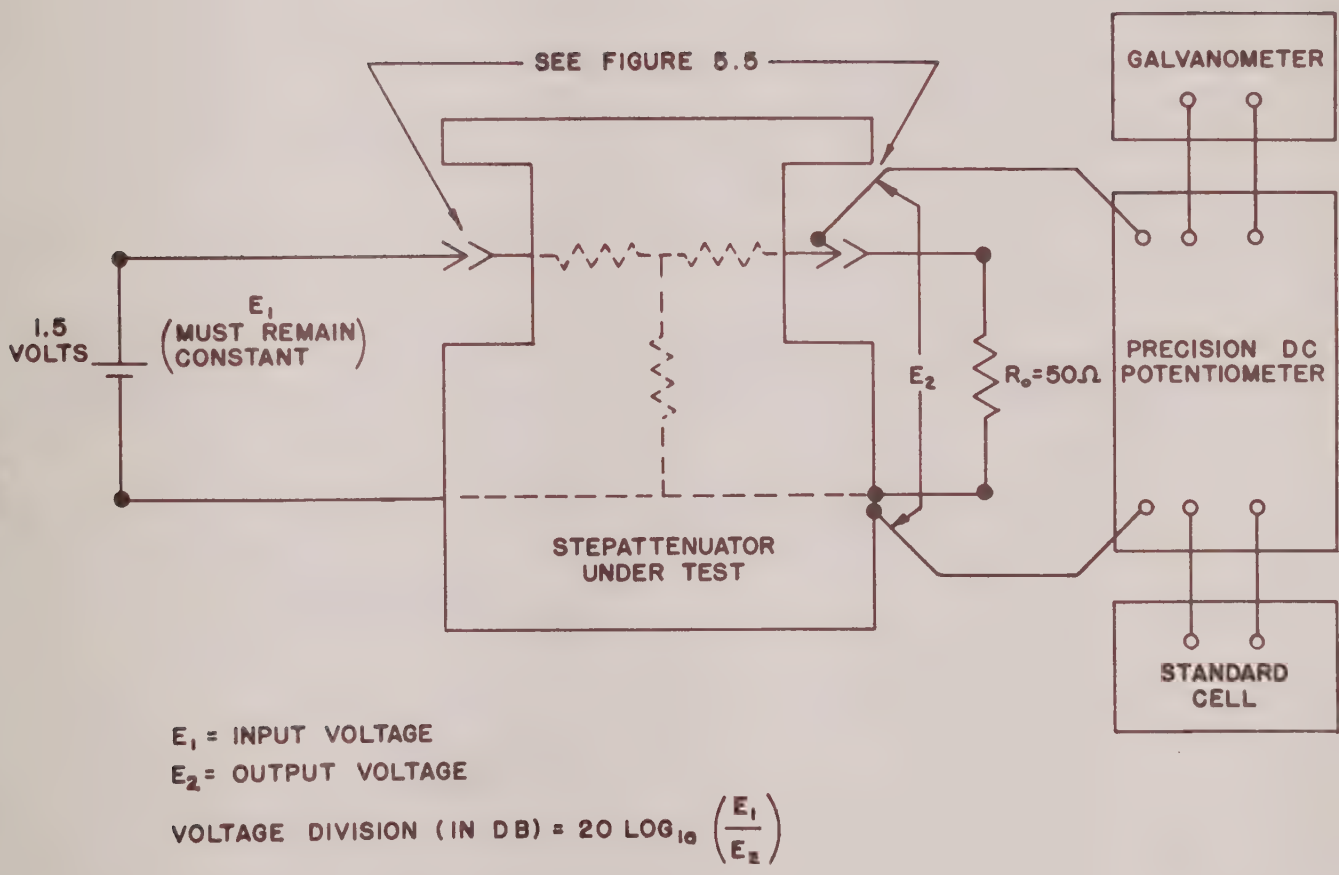
E_1 = Voltage across load when it is connected directly to the voltage source.

E_2 = Voltage across load when the unit under test is inserted between the constant voltage source and the load.

If a true dc insertion loss or voltage division measurement is to be made, the input and output voltages should be made inside the type N connectors directly on the pin of the connector. This is necessary since it is difficult to prevent high contact resistance at the junction of the input voltage leads to the input connector and the junction of the terminating resistor to the output connector. If this measurement is made on the pin inside the connector, the voltage drop due to the contact resistance of the junction of the terminating resistor to the output connector is not represented as a part of the voltage drop across the internal resistance of the Stepattenuators. Since this is a potentiometric voltage measurement, no current flows through the voltage measuring leads and consequently there are no errors due to contact resistance at the junction of these leads with the female pin of the connector.

The common or ground connection of the potentiometer should also be connected directly to the ground (outer conductor) of the type N connector and not to the lead from the load resistor. Contact resistance is also present at this junction and must be avoided to obtain a true voltage division measurement.

A test pin with attached lead (figure 5.5) is recommended for use at each connector when performing these tests. The lead from the load resistor is soldered directly to the test pin whereas the probe from the dc potentiometer is placed directly on the pin of the type N connector. Care should be taken to insure that "cold solder" connections are not present.



E_1 = INPUT VOLTAGE

E_2 = OUTPUT VOLTAGE

VOLTAGE DIVISION (IN DB) = $20 \log_{10} \left(\frac{E_1}{E_2} \right)$

Figure 5.4 Equipment Interconnection for DC Voltage Division Test

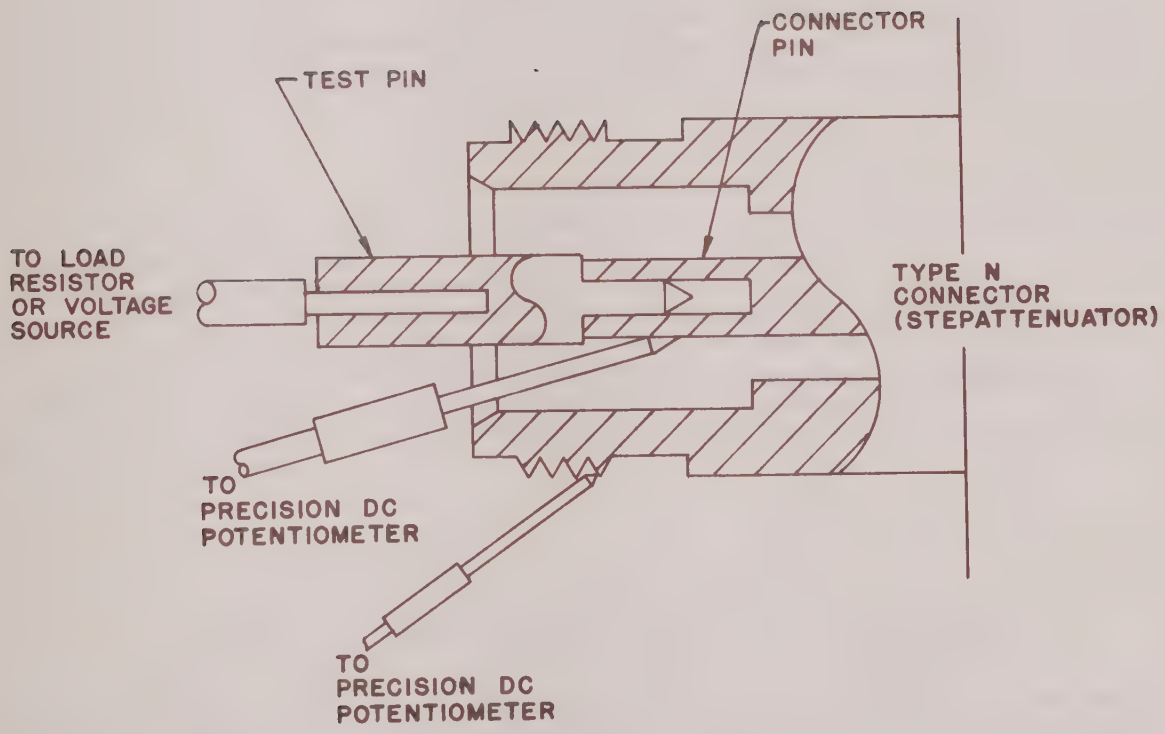


Figure 5.5 Cutaway View of Test Connection for Type N Connectors

5.7.2 DC INSERTION LOSS MEASUREMENT PROCEDURE

The dc insertion loss of the 0-db position of the drum is determined first. The dc insertion loss of each of the other steps is obtained by measuring the voltage across the load with the drum in the 0-db position and then measuring the voltage across the load with the drum in the desired position. All voltage measurements are made using the Precision DC Potentiometer (paragraph 5.7).

a. Connect equipment as shown in figure 5.3, detail A.
b. Measure voltage across R_o. Record value as E_1.
c. Measure source voltage. Record value as E_o.
d. Insert Stepattenuator between source and load as shown in figure 5.3, detail B.
e. Rotate drum to be measured to 0 (db).
f. Measure voltage across R_o. Record value as E_2.
g. Measure source voltage and compare with value of E_o obtained in step c. If voltage has changed, repeat procedure.
h. Calculate dc insertion loss using values obtained in steps b and f as

$$A = 20 \text{ Log } \frac{E_1}{E_2}$$

i. With drum of Stepattenuator set to 0 (db) measure voltage across R_o. Record value as E_1.
j. Measure source voltage E_o. Record value.
k. Rotate drum of Stepattenuator to position of interest.
l. Measure voltage across R_o. Record value as E_2.
m. Measure source voltage E_o and compare with value obtained in step j. If voltage has changed repeat steps i through m.
n. Calculate dc insertion loss using values obtained in steps i and l as follows:

$$A = 20 \text{ Log } \frac{E_1}{E_2}$$

o. Repeat steps i through n for each position of drum.
p. Repeat steps a through o for each drum of Stepattenuator.

5.7.3 DC VOLTAGE DIVISION MEASUREMENT PROCEDURE. The equipment arrangement shown in figure 5.4 is used to measure dc voltage division. In this case the source impedance is not equal to 50 ohms but the input voltage remains constant. If a 1.5-volt battery similar to Eveready No. 6 is used, the source impedance approaches zero.

a. Connect equipment as shown in figure 5.4.
b. On Stepattenuator rotate drum to be measured to 0 (db).
c. Measure source voltage (paragraph 5.7.1). Record value as E_1.
d. Measure voltage across R_o. Record value as E_2.
e. Measure source voltage and compare with value of E_1 obtained in step c. If voltage has changed, repeat procedure.
f. Calculate voltage division in decibels using values obtained in steps c and d as follows:

$$V.D. = 20 \text{ Log}_{10} \frac{E_1}{E_2}$$

g. Measure source voltage. Record value as E_1.

h. Rotate drum to position of interest.

i. Measure voltage across R_o. Record value as E_2.

j. Measure source voltage and compare with value obtained in step g. If voltage has changed repeat steps g through j.

k. Calculate dc voltage division using values obtained in steps g and i as follows:

$$V.D. = 20 \text{ Log}_{10} \frac{E_1}{E_2}$$

l. Repeat steps g through k for each position of drum.

m. Repeat steps b through l for each drum of Stepattenuator.

SECTION VI

PARTS BREAKDOWN

6.1 PARTS BREAKDOWN

The parts breakdown for the Precision Stepattenuators, Models 60A - 64A are given in Table 6.1.

TABLE 6.1

STEPATTENUATOR PARTS BREAKDOWN

Quantity	Nomenclature	Weinschel Part No.
	Model 60A Parts Breakdown	
1	Interconnecting Cable Assembly	B89-206
1	Drum B	(See Table 6.2)
1	Drum C	(See Table 6.2)
	Model 61A Parts Breakdown	
1	Drum B	(See Table 6.2)
	Model 62A Parts Breakdown	
1	Drum C	(See Table 6.2)
	Model 63A Parts Breakdown	
1	Drum A	(See Table 6.2)
	Model 64A Parts Breakdown	
2	Interconnecting Cable Assembly	B89-195
1	Drum A	(See Table 6.2)
1	Drum B	(See Table 6.2)
1	Drum C	(See Table 6.2)

TABLE 6.2

ATTENUATOR DRUM PARTS BREAKDOWN

Quantity	Nomenclature	Weinschel Part No.
	Drum A Parts Breakdown	
1	Pad, Attenuator, 0 db	B89-174-0
1	Pad, Attenuator, 3.0 db	B89-174-3
1	Pad, Attenuator, 3.1 db	B89-174-3.1
1	Pad, Attenuator, 3.2 db	B89-174-3.2
1	Pad, Attenuator, 3.3 db	B89-174-3.3
1	Pad, Attenuator, 3.4 db	B89-174-3.4
1	Pad, Attenuator, 3.5 db	B89-174-3.5
1	Pad, Attenuator, 3.6 db	B89-174-3.6
1	Pad, Attenuator, 3.7 db	B89-174-3.7
1	Pad, Attenuator, 3.8 db	B89-174-3.8
1	Pad, Attenuator, 3.9 db	B89-174-3.9
1	Pad, Attenuator, 4.0 db	B89-174-4
1	Switch Assembly	D89-97-1
1	Cable Assembly	B101-175
1	Cable Assembly	B101-16
	Drum B Parts Breakdown	
1	Pad, Attenuator, 0 db	B89-174-0
1	Pad, Attenuator, 1 db	B89-174-1
1	Pad, Attenuator, 2 db	B89-174-2
1	Pad, Attenuator, 3 db	B89-174-3
1	Pad, Attenuator, 4 db	B89-174-4
1	Pad, Attenuator, 5 db	B89-174-5

(Cont.)

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